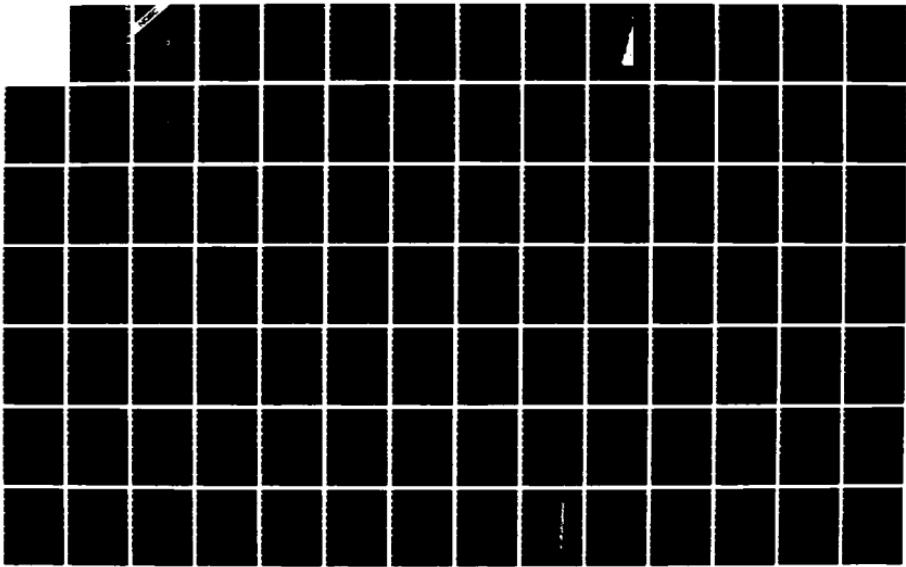


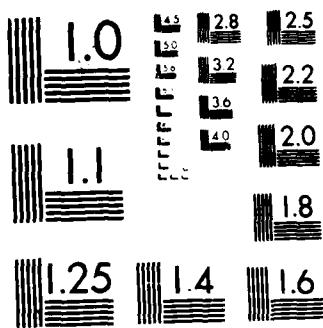
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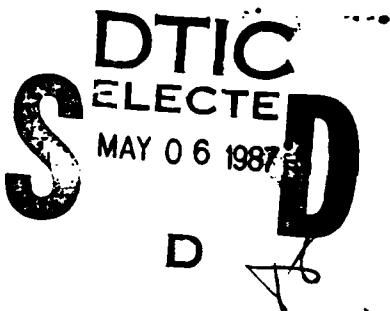
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Technical Document 1043
November 1986

Biological Environmental Arctic Project (BEAP) Preliminary Data

(Arctic West Summer 1986 Cruise)

AD-A179 818



David Lapota
Stephen H. Lieberman

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This work was performed by the Environmental Sciences Division, Code 52, Naval Ocean Systems Center, for Director, Arctic Submarine Laboratory.

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INTRODUCTION

The primary objective of the Biological Environmental Arctic Project (BEAP) was to measure in situ bioluminescence and transmissometry with a suite of related optical, chemical, and biological parameters to establish correlates for a predictive model of bioluminescence in near-surface arctic waters.

In previous years, these measurements were conducted from the USCG NORTHWIND (WAGB 282) during ARCTIC EAST SUMMER 1985 (AES 85), which operated in waters east of Greenland and west of Spitzbergen as far north as 82°, and again during the summer of 1986 as NORTHWIND operated off the west coast of Greenland in Baffin Bay and Kane Basin.

This preliminary report emphasizes data collected during ARCTIC WEST SUMMER 1986 (AWS 86) operations in the Beaufort Sea and includes some first impressions of what the data represent. Additionally, a more thoroughly analyzed data set from the AES 85 operations in the Greenland Sea was presented by Stephen H. Lieberman at the American Geophysical Union's annual meeting during the American Society of Limnology and Oceanography section in January 1986.

AWS 86 operations, which took place from 17 September to 1 October 1986, were conducted from the USCG POLAR STAR (WAGB 10). The first 2 days of the operation were hampered by poor weather, thus delaying the transfer of scientists and equipment to the ship from Barrow, Alaska. The overall study area was in the Beaufort Sea. For the most part, BEAP stations were confined to the second week of operations. In all, five stations were attempted. The first four stations were positioned in pack ice (10-9/10 percent coverage) in the area 70°30' to 73°35'N by 142° to 141°W (table 1 a. figure 1). The fifth station was southwest of the first stations in open water adjacent to the ice edge (71°30'N, 147°32'W).

Table 1. Station positions.

Station	Position	Time/Date (Z)	Depth (m)	Ice Coverage (percent)
1	73°6'N 141°24'W	0756/21 Sep 86	2.769	7/10
2	73°28'N 141°14.6'W	0559/25 Sep 86	3.495	9/10
3	72°54'N 141°12'W	0558/26 Sep 86	3.285	9/10
4	72°34'N 141°36'W	0540/27 Sep 86	3.281	8/10
5	71°30'N 147°32.4'W	0533/29 Sep 86	2.686	0

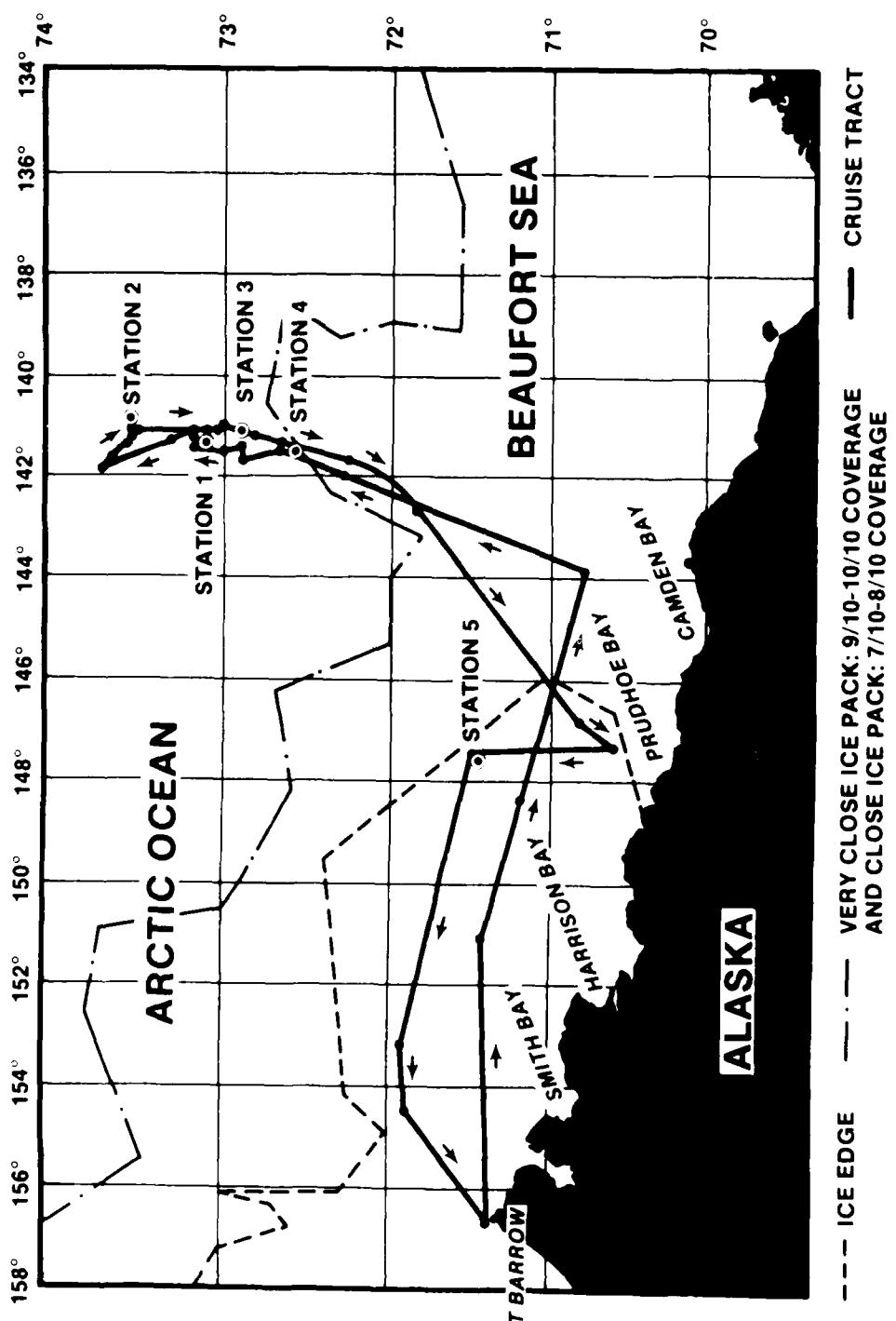


Figure 1. Cruise track.

DATA COLLECTION

Vertical bioluminescence, optical transmission, and temperature profiles to approximately 100 m deep were taken at night with a submersible bathyphotometer in polynyas.* Plankton samples were pumped from the bathyphotometer to a plankton collection tank on deck via a 1-inch inside diameter (ID) hose. The submersible bathyphotometer system pumps seawater past an RCA-8575 photomultiplier tube (PMT) operating in the single photon count mode and consists of a filter wheel disc with a capacity for carrying 10 optical filters and a depth sensor (figure 2). Neutral density filters of varying attenuation powers complement the filter set, and all components are contained in an aluminum pressure housing. A 1/3-hp Gould submersible pump (Model 10 EJ) with a flow rate of 0.81 s^{-1} was mounted on the exterior of the detector to pull seawater through a viewing chamber fitted with an ultraviolet transmitting window. A lighttight 10-cm ID s-shaped plastic black pipe was used for conveying seawater into the detector, which abruptly narrows down to a 6-mm ID arm of the viewing chamber. The sudden reduction in pipe size introduces turbulence and maintains a constant stimulus to the plankton being viewed. The detector was deployed by the ship's hydrographic winch with a steel cable to a maximum depth of 100 m. Two electrical cables strapped together supplied power to the detector and pump and then returned the PMT signal to the ship-board electronics. Light transmission was measured using a Sea Tech 0.25-m beam transmissometer mounted vertically on the bathyphotometer. The transmissometer uses a light-emitting diode (LED) that emits at 680 nm. At this wavelength, light absorption by dissolved organics is minimal.

Effluent from the pumping system was used to deliver seawater to the ship's laboratory to measure conductivity, pH, and chlorophyll fluorescence. Water temperature and conductivity were measured using Sea Bird temperature (Model SBE-3) and conductivity sensors (Model SBE-4) in conjunction with an SBE 11/4 Deck unit for digitizing sensor frequency data. One temperature sensor was mounted directly on the bathyphotometer for in situ temperature measurements. A second temperature sensor was inserted in the seawater manifold in the ship's laboratory between the conductivity sensor and the pH electrode. Seawater pH was measured in the flowing seawater stream with a Corning semimicro combination electrode (Corning No. 476055). In vivo chlorophyll *a* fluorescence was measured on the flowing seawater stream from the bathyphotometer with a Turner Designs (Model 10-005R) fluorometer. Fluorescence values are reported as relative fluorescence.

Two data acquisition systems were used to record data from the bathyphotometer profiles and shipboard measurements. The signal pulses from the bioluminescence PMT were handled in several ways. Continuous 30-s sample blocks were obtained with an Ortec scaler (Model 874) and recorded as an accumulated count on an Otrona microcomputer. High time resolution data of the bioluminescence signal were obtained by bringing the PMT signal pulses into time channels of 10 ms on a Davidson multichannel analyzer. These data were again recorded in 1,023 channel blocks on the microcomputer. In addition, analog signals from the transmissometer and fluorometer were simultaneously recorded along with the bioluminescence signal. The other data acquisition system consisted of an Analog Devices uMac 5000 measurement and control system linked to a Compaq personal computer. Analog signals from the bioluminescence PMT,

*Areas of open water in sea ice (Russian).

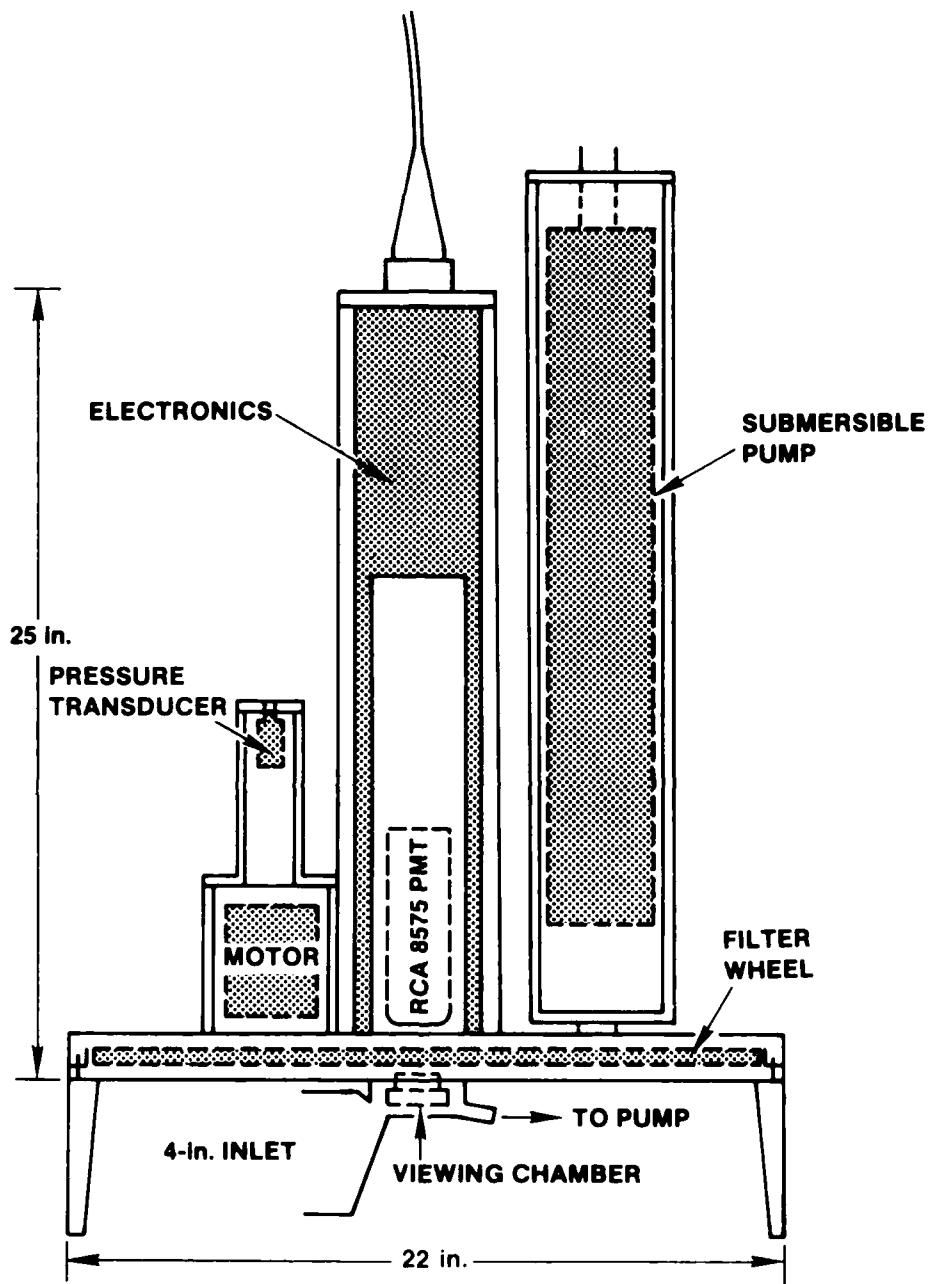


Figure 2. Bathyphotometer.

depth transducer, transmissometer, pH electrode, fluorometer signal, and fluorometer range were sampled using an integrating analog to digital (A/D) board on the uMac processor and combined with digital signals from the temperature and conductivity sensors. During vertical profiling, a 2-s sampling rate was used and a bathyphotometer lowering rate of 8 m min^{-1} corresponds to a vertical spatial sampling resolution of about 0.3 m.

PLANKTON COLLECTIONS

The 1-inch ID hose used for pumping plankton samples at depth to the shipboard plankton collection tank separated from the pump at depth at stations 2 and 4. Discrete plankton samples (40 l) at various depths were collected at stations 3 and 5. Several vertical plankton net tows (1/2-m ring, 2-m length, 500- μm net, and collection cup porosity netting) accompanied each of the five stations either from 300 m-0 and/or 100 m-0. Supplemental drifting plankton net collections were also examined on board the ship for identifying luminous plankton species responsible for the measured bioluminescence (see tables 2 and 3). Individual phyto- and zooplankters were isolated from the plankton tows and individually tested for bioluminescence in the laboratory plankton test chamber (LPTC) (figure 3). To facilitate this testing, isolated organisms were placed into quartz sample holders with 6 ml of filtered seawater. The lucite base of the sample holders was drilled to accommodate water removal by an applied vacuum, while precut Whatman GF/C filter discs lined the bottoms of the holders to retain the test organism following water removal. To observe the luminescence from the vacuum stimulated organisms, an RCA 8575 PMT was mounted onto the test chamber port. The output of the PMT (high time resolution) was displayed as a time sequence of counts/40 ms time channel from the induced flash. The "instantaneous" intensity of the signal is proportional to the number of counts in each channel. Recovery of the luminous plankter was made by several washings of the sample vial with filtered seawater into a beaker and then preserved in a buffered 2.5-percent formalin solution for later identification. In all, 187 plankters were tested and of these, 53 proved to be luminescent. The luminescent "isolate" data represented by dinoflagellates, larval, and adult copepods identify which species contributed to the measured bioluminescence. All collected plankton samples were washed into sample jars with filtered seawater and preserved in a buffered solution of 2.5-percent formalin. Analysis of these samples will be completed in FY 87.

Table 2. Plankton net hauls.

No.	Time/Date (Z)	Position	Depth (m-0)	Size Mesh (μ m)
1	1020/21 Sep 86	73°6'N 141°24'W	100	500
2	0330/24 Sep 86	73°32.7'N 141°27.4'W	15 (drifting)	30
3	0936/24 Sep 86	73°32.7'N 141°27.4'W	15 (drifting)	30
4	0740/25 Sep 86	73°28.7'N 141°14.6'W	300	500
5	0810/25 Sep 86	73°28.7'N 141°14.6'W	200	500
6	0837/25 Sep 86	73°28.7'N 141°14.6'W	100	500
7	0845/25 Sep 86	73°28.7'N 141°14.6'W	10 (drifting)	30
8	1020/26 Sep 86	72°54'N 141°12'W	500	500
9	0840/27 Sep 86	72°34'N 141°36.6'W	300	500
10	0915/27 Sep 86	72°34'N 141°36.6'W	100	500
11	0920/27 Sep 86	72°34'N 141°36.6'W	20 (drifting)	30
12	0930/29 Sep 86	71°31'N 147°41'W	300	500
13	1000/29 Sep 86	71°31'N 147°41'W	100	500
14	1005/29 Sep 86	71°31'N 147°41'W	20 (drifting)	30
15	0645/30 Sep 86	72°17.8'N 151°3.1'W	300	500
16	0715/30 Sep 86	72°17.8'N 151°3.1'W	100	500

Table 3. Discrete plankton samples (20- μm porosity collection cups).

Station	Time/Date (Z)	Position	Depth (m)	Sample Volume (l)
3	0632/26 Sep 86	72°54'N 141°12'W	100	60
	0645/26 Sep 86	72°54'N 141°12'W	90	60
	0710/26 Sep 86	72°54'N 141°12'W	80	60
	0748/26 Sep 86	72°54'N 141°12'W	70	40
	0802/26 Sep 86	72°54'N 141°12'W	60	40
	0820/26 Sep 86	72°54'N 141°12'W	50	40
	0840/26 Sep 86	72°54'N 141°12'W	40	40
	0855/26 Sep 86	72°54'N 141°12'W	30	40
	0918/26 Sep 86	72°54'N 141°12'W	20	40
	0932/26 Sep 86	72°54'N 141°12'W	10	40
4	0948/26 Sep 86	72°54'N 141°12'W	3.7	40
	0622/27 Sep 86	72°34'N 141°36.6'W	100	40
	0635/27 Sep 86	72°34'N 141°36.6'W	91	40
	0648/27 Sep 86	72°34'N 141°36.6'W	82	40

Table 3. Discrete plankton samples (20- μm porosity collection cups) (cont.).

Station	Time/Date (Z)	Position	Depth (m)	Sample Volume (l)
5	0558/29 Sep 86	71°30.5'N 147°32.4'W	92.5	40
	0612/29 Sep 86	71°30.5'N 147°32.4'W	80	40
	0630/29 Sep 86	71°30.5'N 147°32.4'W	70	40
	0630/29 Sep 86	71°30.5'N 147°32.4'W	60	40
	0641/29 Sep 86	71°30.5'N 147°32.4'W	48	40
	0653/29 Sep 86	71°30.5'N 147°32.4'W	37.7	40
	0705/29 Sep 86	71°30.5'N 147°32.4'W	28	40
	0725/29 Sep 86	71°30.5'N 147°32.5'W	20	40
	0807/29 Sep 86	71°30.5'N 147°32.5'W	10	40
	0823/29 Sep 86	71°30.5'N 147°32.5'W	4	40

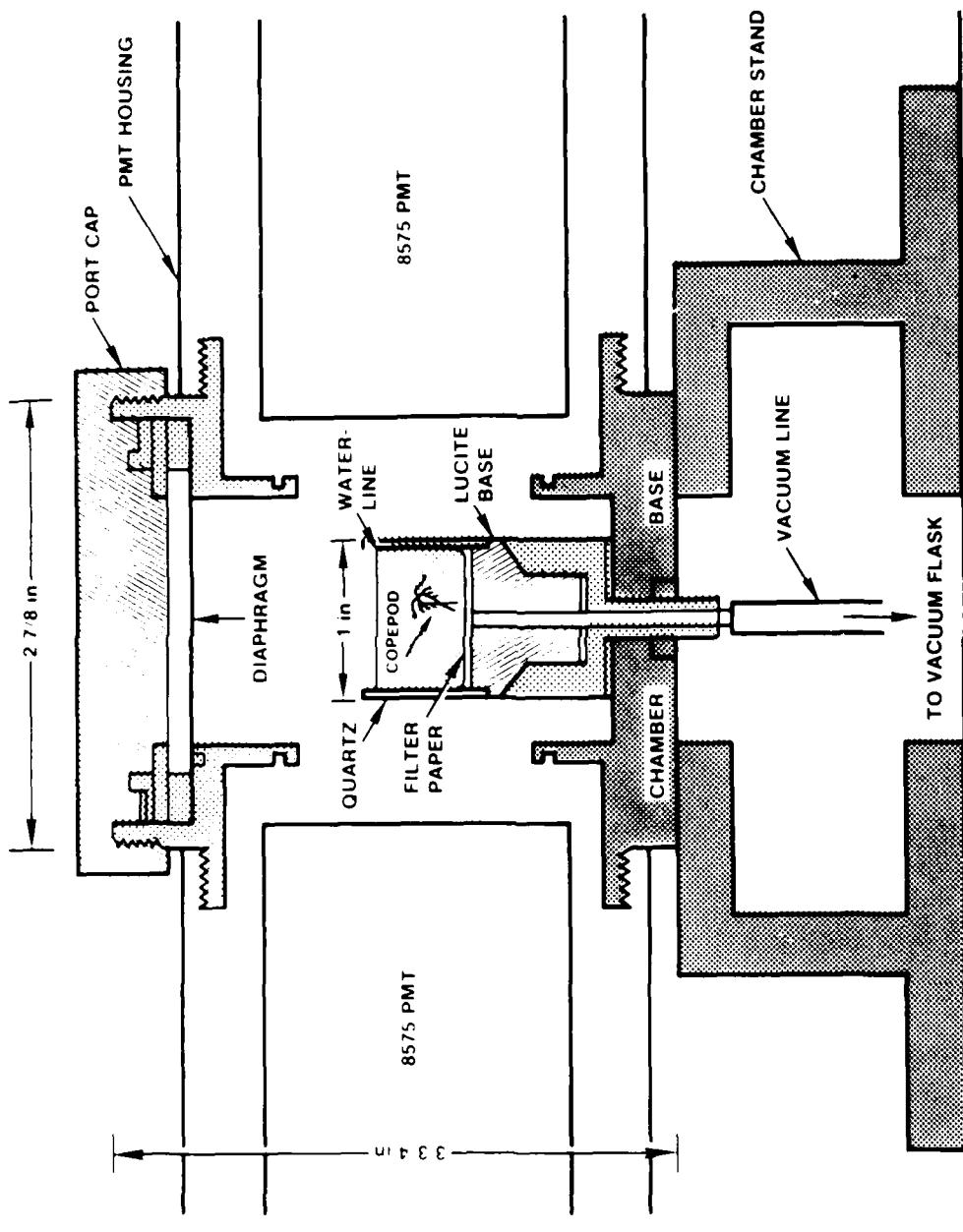


Figure 3. Laboratory plankton test chamber.

FIRST IMPRESSIONS

Of the five stations attempted, the last four yielded information that is interesting and unique. Instrumentation problems were experienced at a depth of 60 m during the first station, and any acquired data must be considered suspect. The entire system was checked, cleaned, and reassembled. BNC cables were replaced from the cable junction box to the multiplex module while the submarine cable connector plug was recleaned and tightened. No further problems were experienced with the fish during the remaining stations. While Sea Bird temperature frequency was recorded on both data acquisition systems, one of the algorithms used for interpreting seawater temperature was inappropriate for use in the cold arctic waters and must be recalibrated. Temperature profiles are included for completeness and will be corrected as soon as data from CTD cast taken just prior to the bathyphotometer drop become available and are compared with values recorded by the uMac-5000 measurement and control system.

Bioluminescence structure and intensity were very similar at stations 2, 3, and 4. In each of these profiles, the lowering rate was held as constant as possible, but between stations, the lowering rate ranged from 3.1 m min^{-1} to 9 m min^{-1} with sampling resolution of 1.55 to 4.5 m. The spatial sampling resolution with the uMac-5000 measurement and control system ranged from 0.1 to 0.3 m. Several distinct layers were always observed within the upper 50 m of the profile. Below 50 m, the bioluminescence intensity was markedly less. The intensity associated with these layers was $1 \times 10^5 \text{ PMT counts s}^{-1}$ ($3 \times 10^6 \text{ photons s}^{-1} \text{ cc}^{-1}$ of seawater) and is characteristic of that found in other open ocean measurements. By testing some of the plankton collections, we observed that the only plankton capable of emitting light sampled by the bathyphotometer in this area, below the ice pack, were nauplii or larval stages of a luminescent copepod *Metridia longa* (see appendix C). The adults were sampled by the detector, but less frequently. Many dinoflagellate cells of *Protoperoedinium* and *Ceratium* were tested; however, no luminescence was observed. Other larger zooplankters captured in deeper net tows were observed to luminesce. At station 5, the bioluminescence structure and intensity were completely different from preceding stations. The peak intensity was centered at about 15 m below the sea surface and exhibited an intensity of approximately $7.5 \times 10^6 \text{ PMT counts s}^{-1}$ ($2.3 \times 10^8 \text{ photons s}^{-1} \text{ cc}^{-1}$ of seawater) or a factor of 75 greater than the peak intensity values exhibited at the pack ice stations. The intensity dropped by a factor of 50 from its peak value at 15 m to that found at 92 m. This station shows a warm water intrusion within the cold arctic water. The dynamics of the cold and warm water mixing appear to have imparted some spatial structure to the optical transmission of seawater and chlorophyll fluorescence. The biological collections taken at this station show the presence of not only luminous larval stages of copepods but a significant contribution by several other species of the luminescent dinoflagellate *Protoperoedinium*.

**APPENDIX A
BATHYPHOTOMETER PROFILES**

STATION 2 PROFILE 1

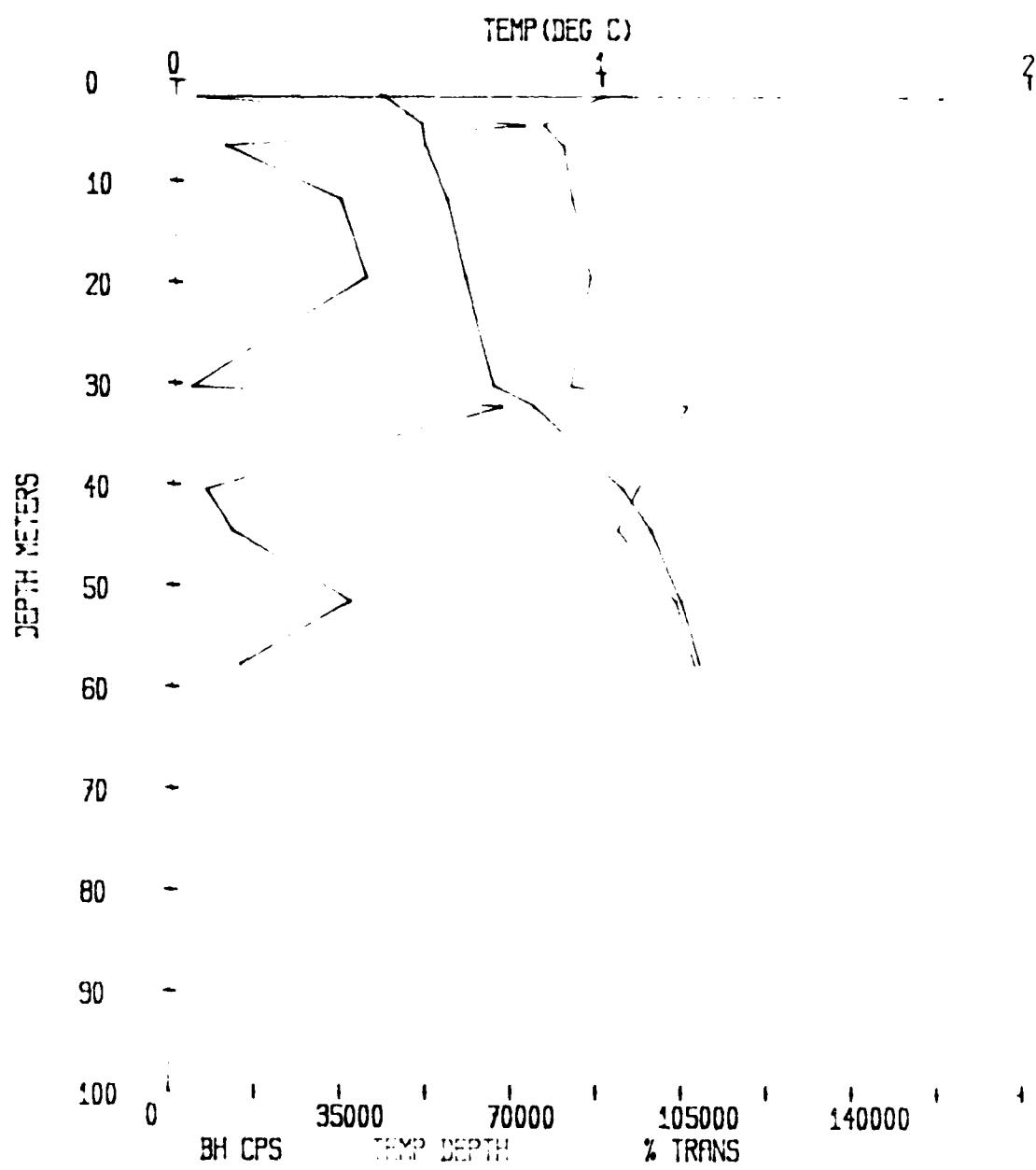


Figure A-1

STATION 2 PROFILE 1

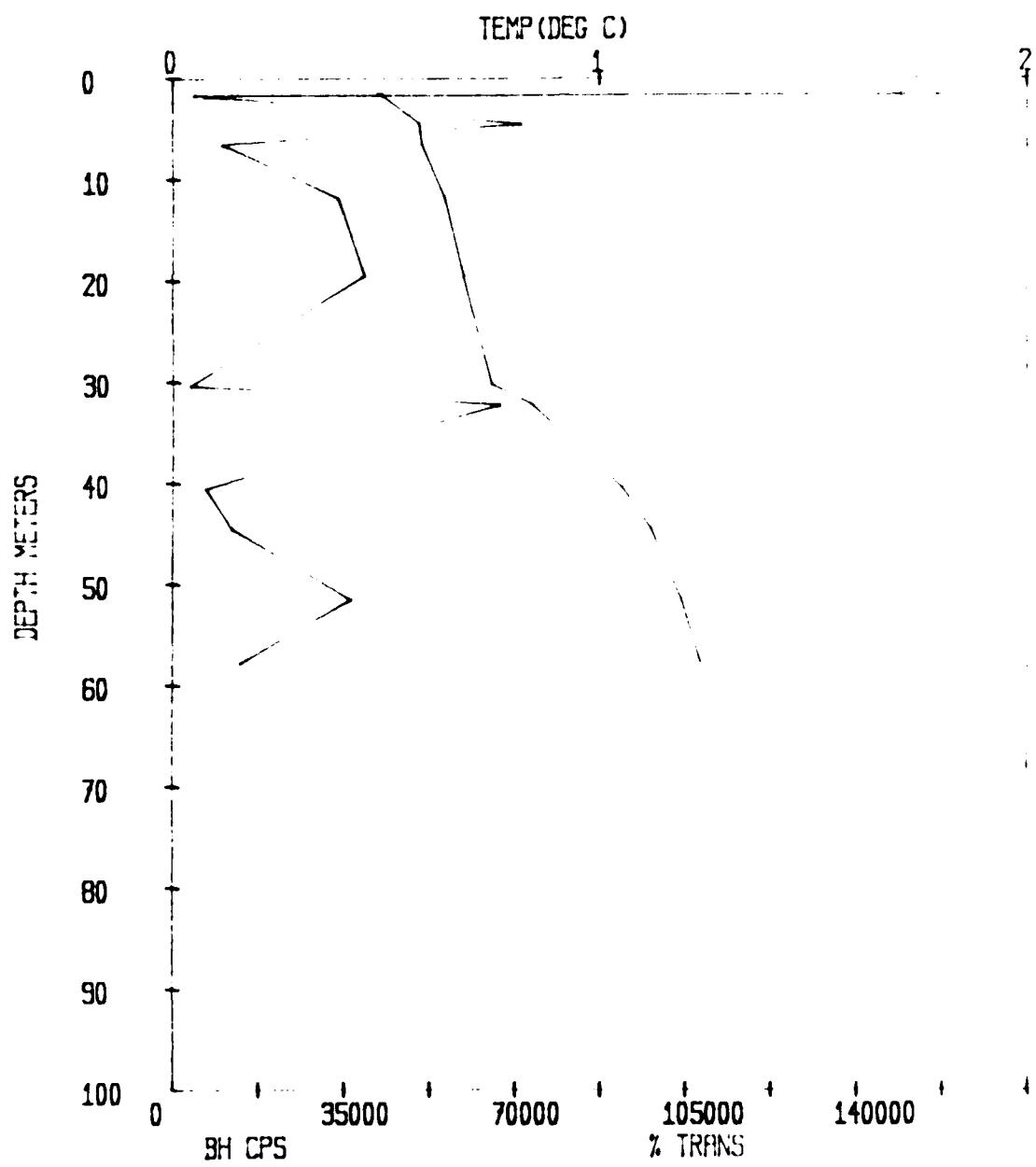


Figure A-2

STATION 2 COMING UP

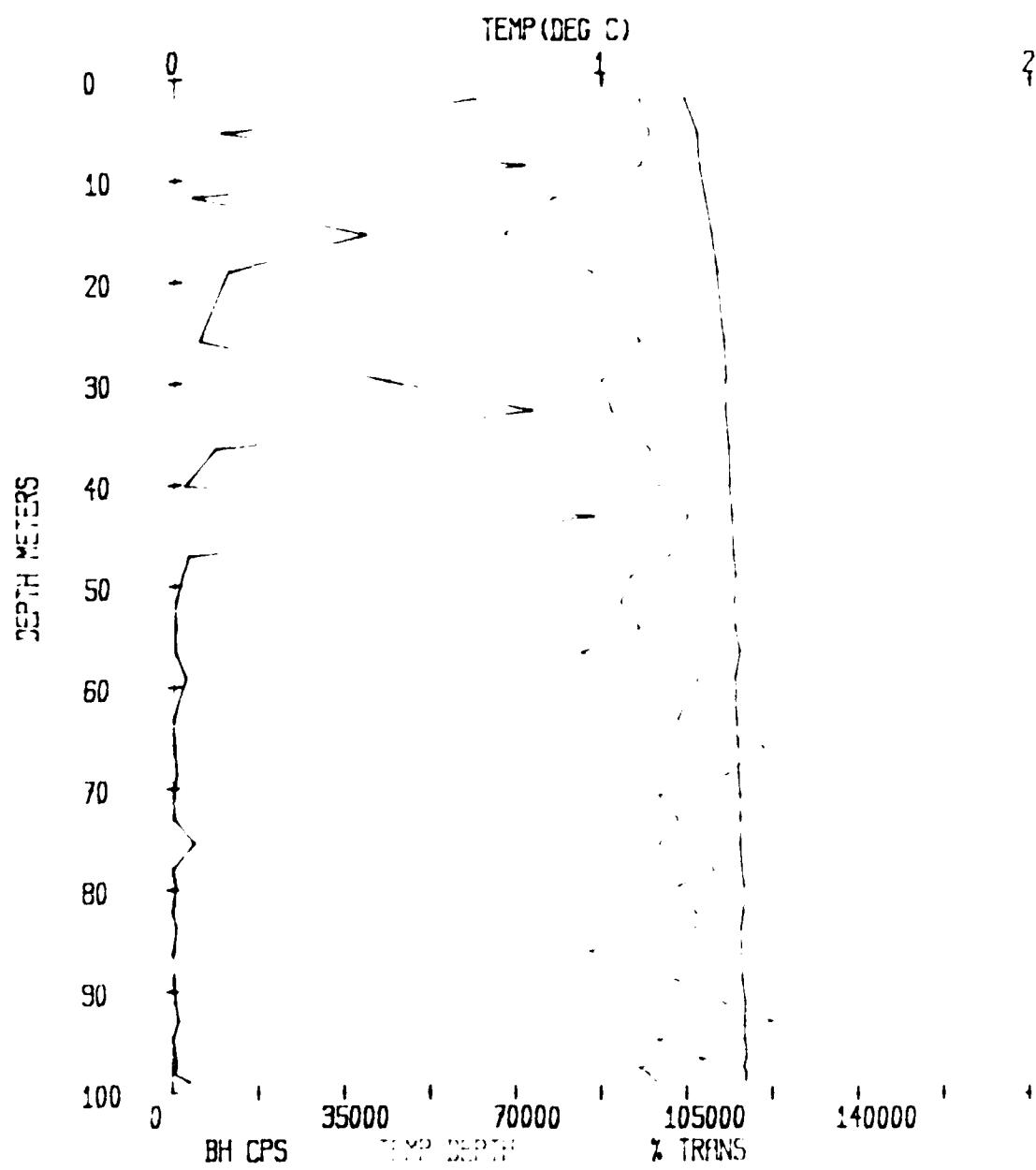


Figure A-3

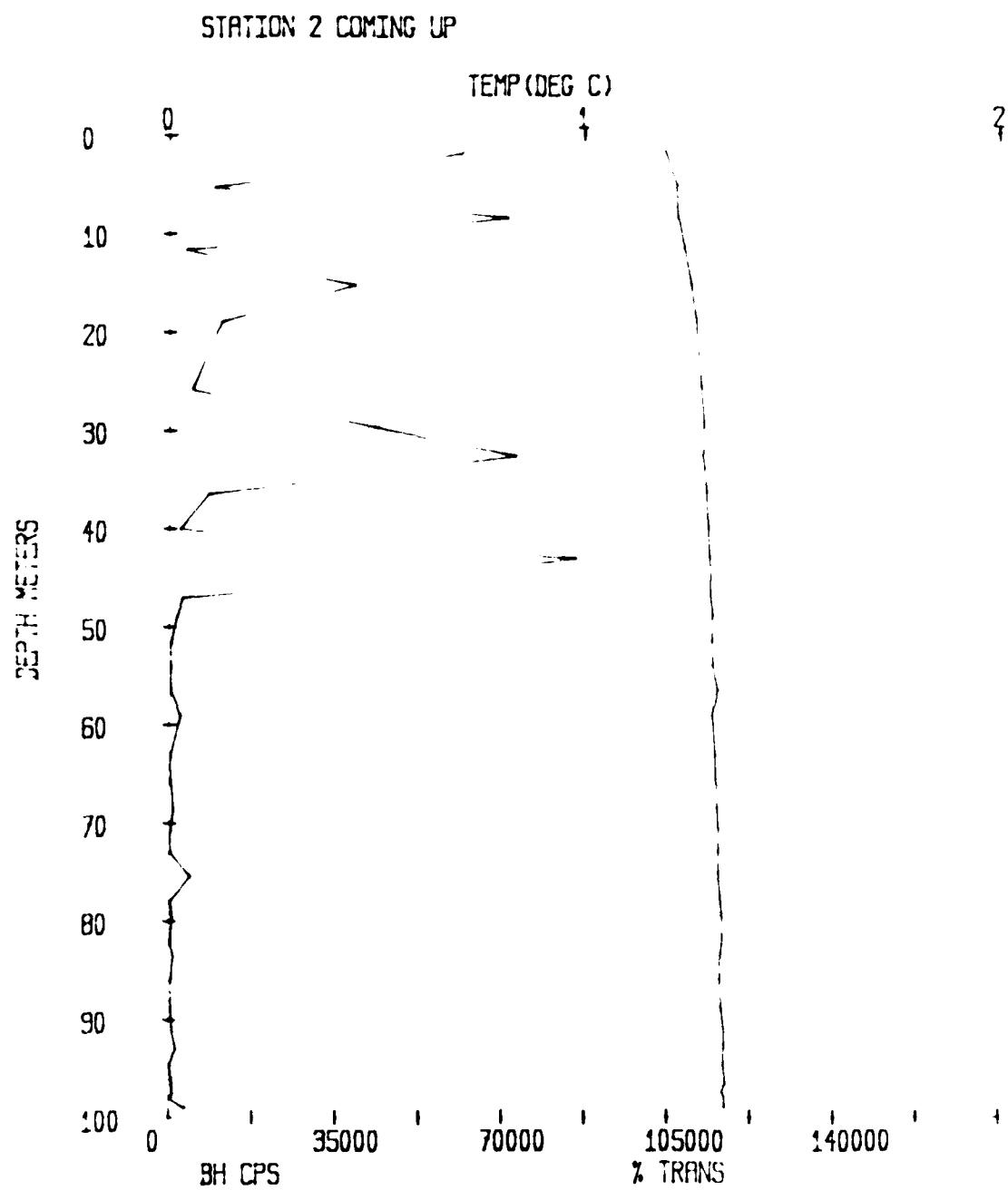


Figure A 4

STATION 3 GOING DOWN

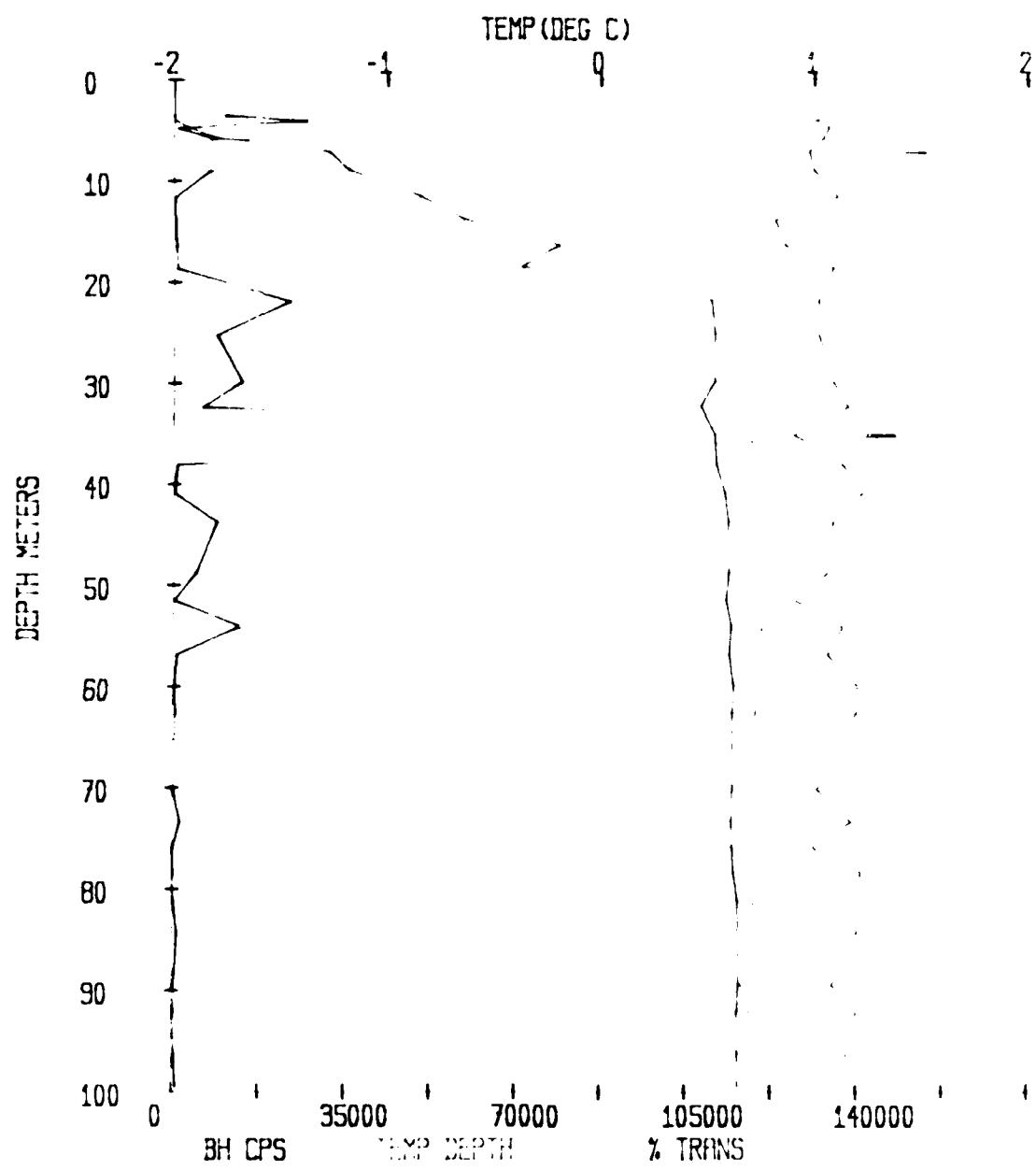


Figure A 5

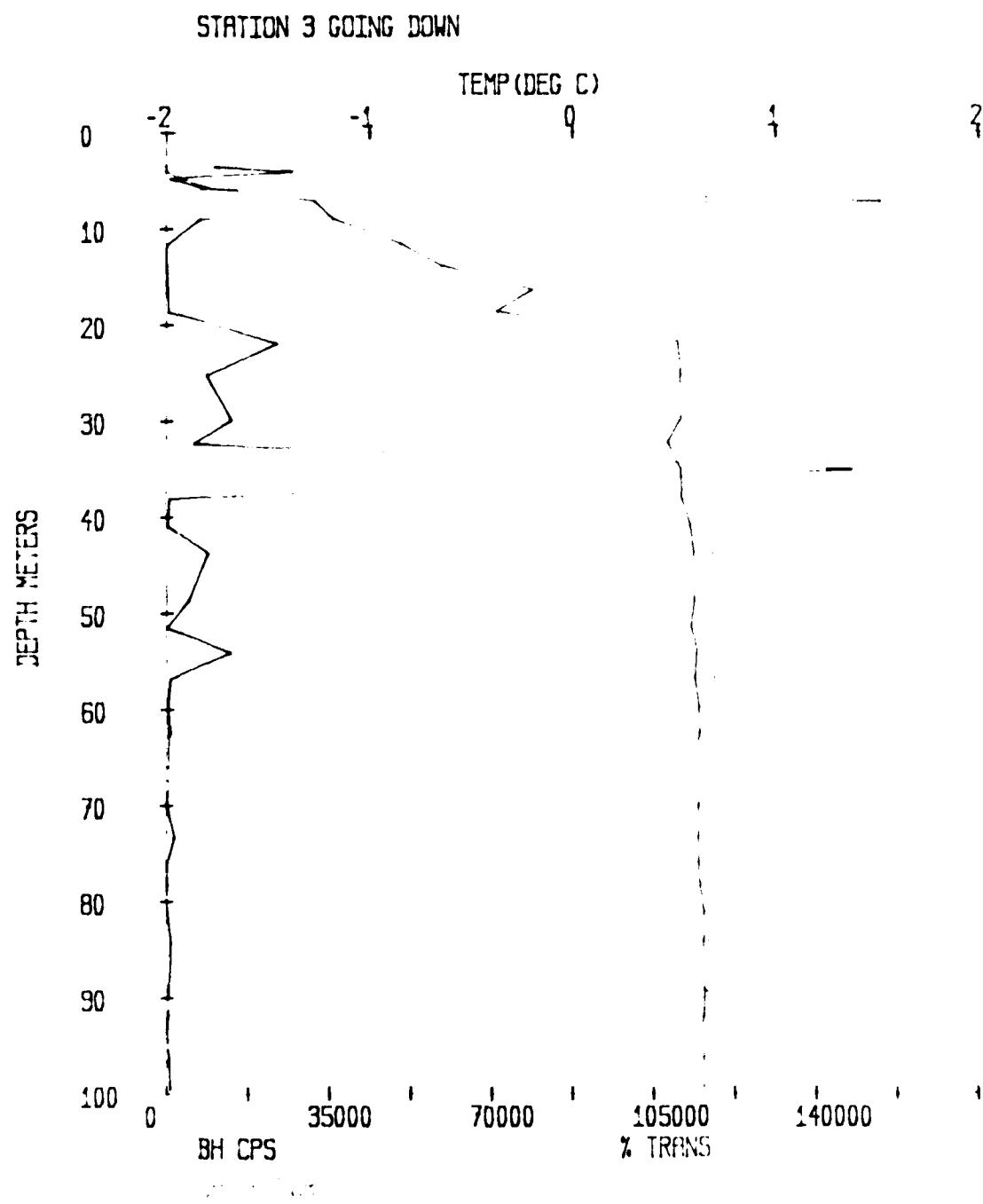


Figure A-6

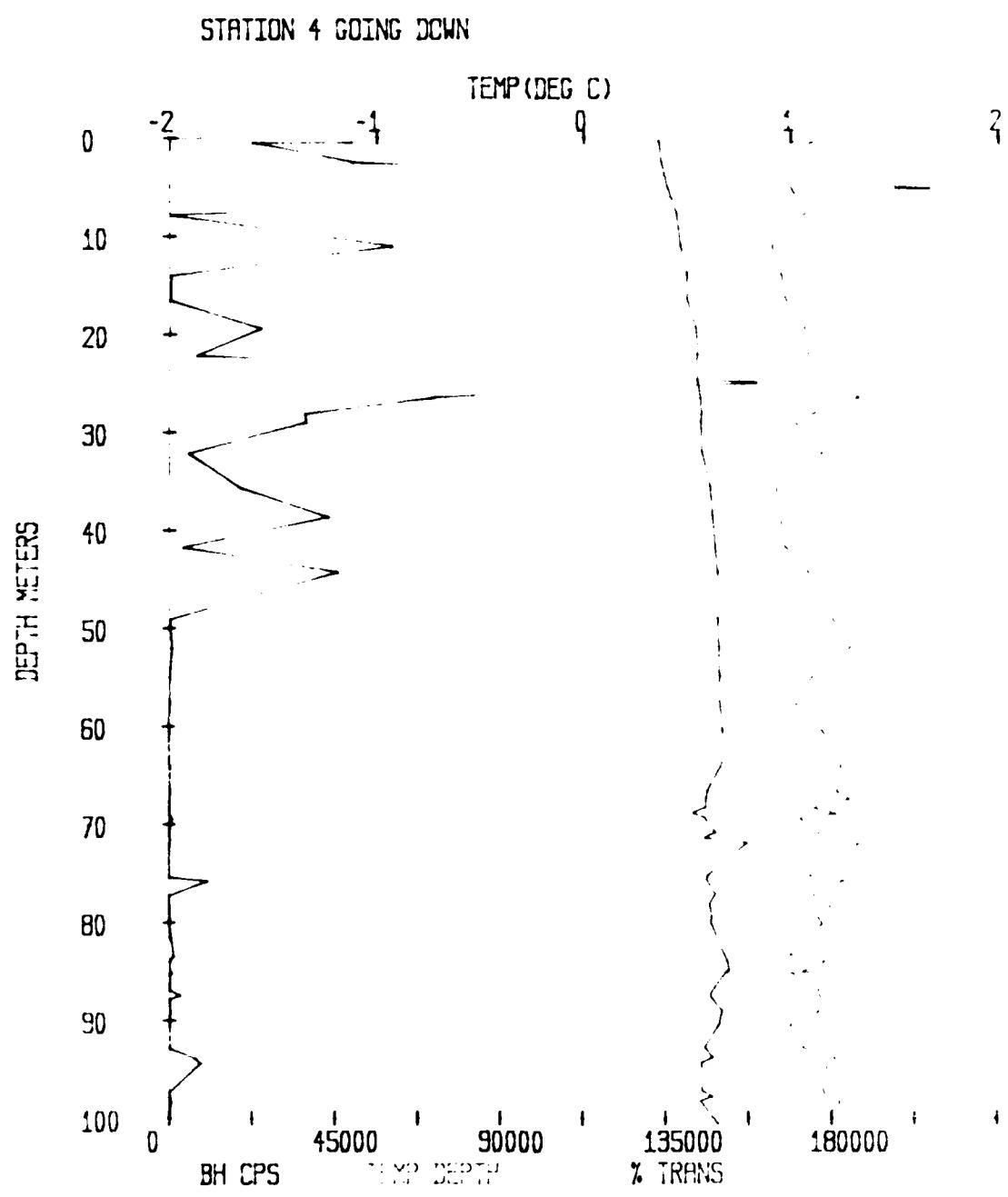


Figure A-7

STATION 4 GOING DOWN

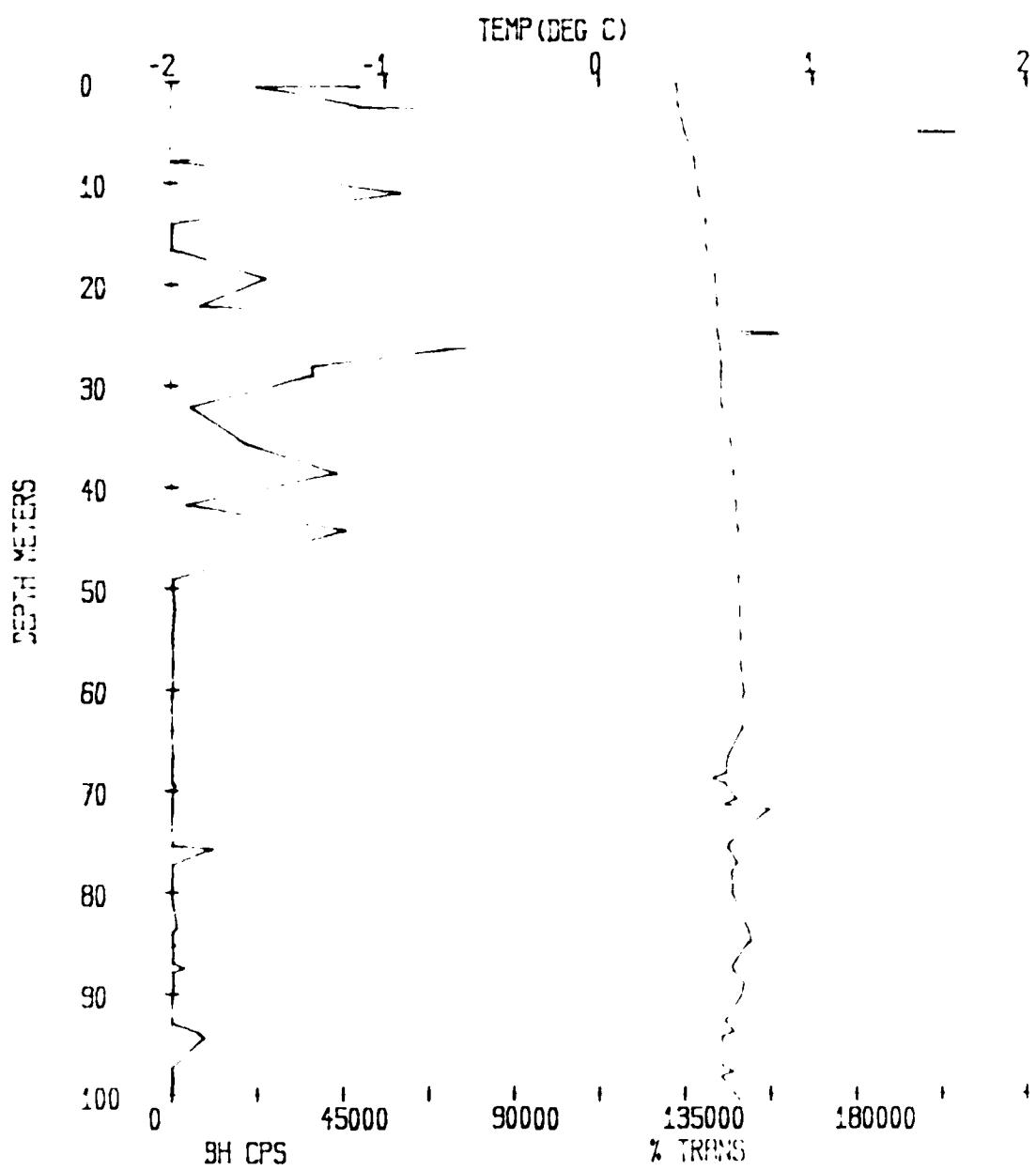


Figure A.8

STATION 5 GOING DOWN

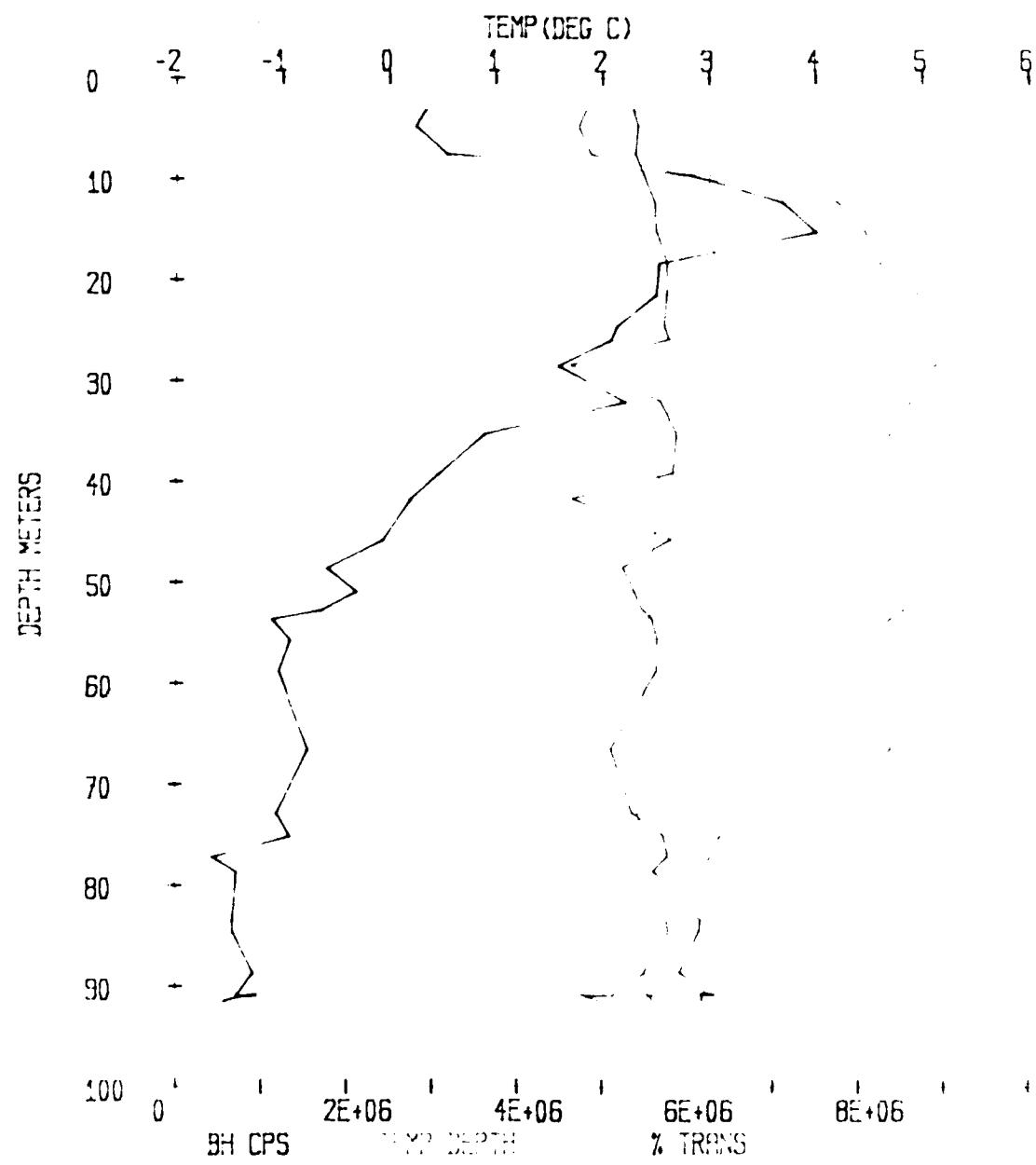


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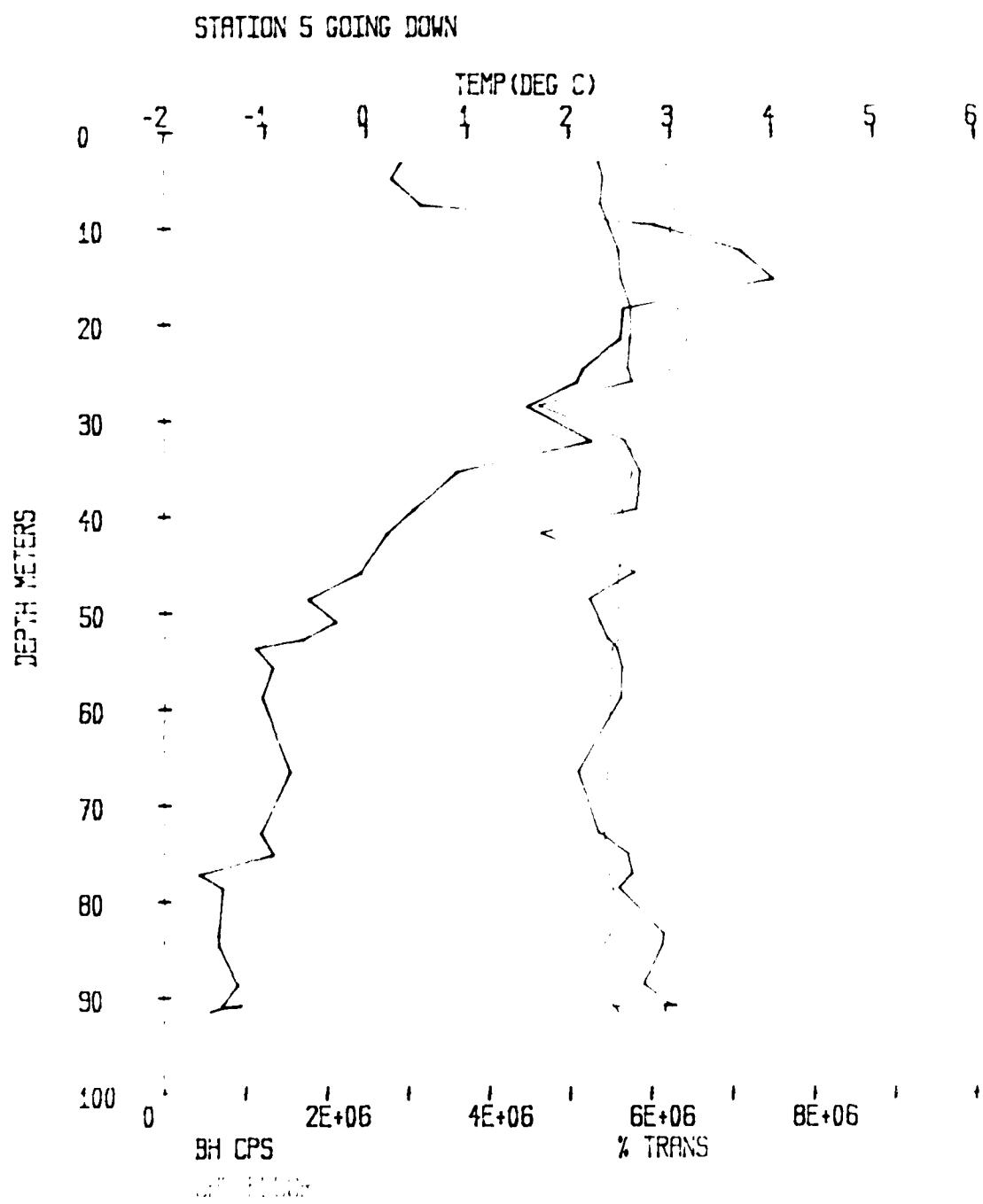


Figure A-10

APPENDIX B
HIGH TIME RESOLUTION SCANS OF
BIOLUMINESCENCE EVENTS AT DEPTH

09/28/88 09:51:34 BB ////ND2/ND2/ND1/D

SAMPLES STATION 9 9.7M 10 MSEC ND1

1. 0E+08

1. 2E+08

8E+07

4E+07

PHOTONS/CHANNEL

B-2

TIME SEC (CONSEC 10 MSEC TIME BINS)

Figure B-1

03/26/88 09:39:15 BB ////ND2/ND2/ND1/D

SAMPLE 9 STATION 9 10 M 10SEC ND1

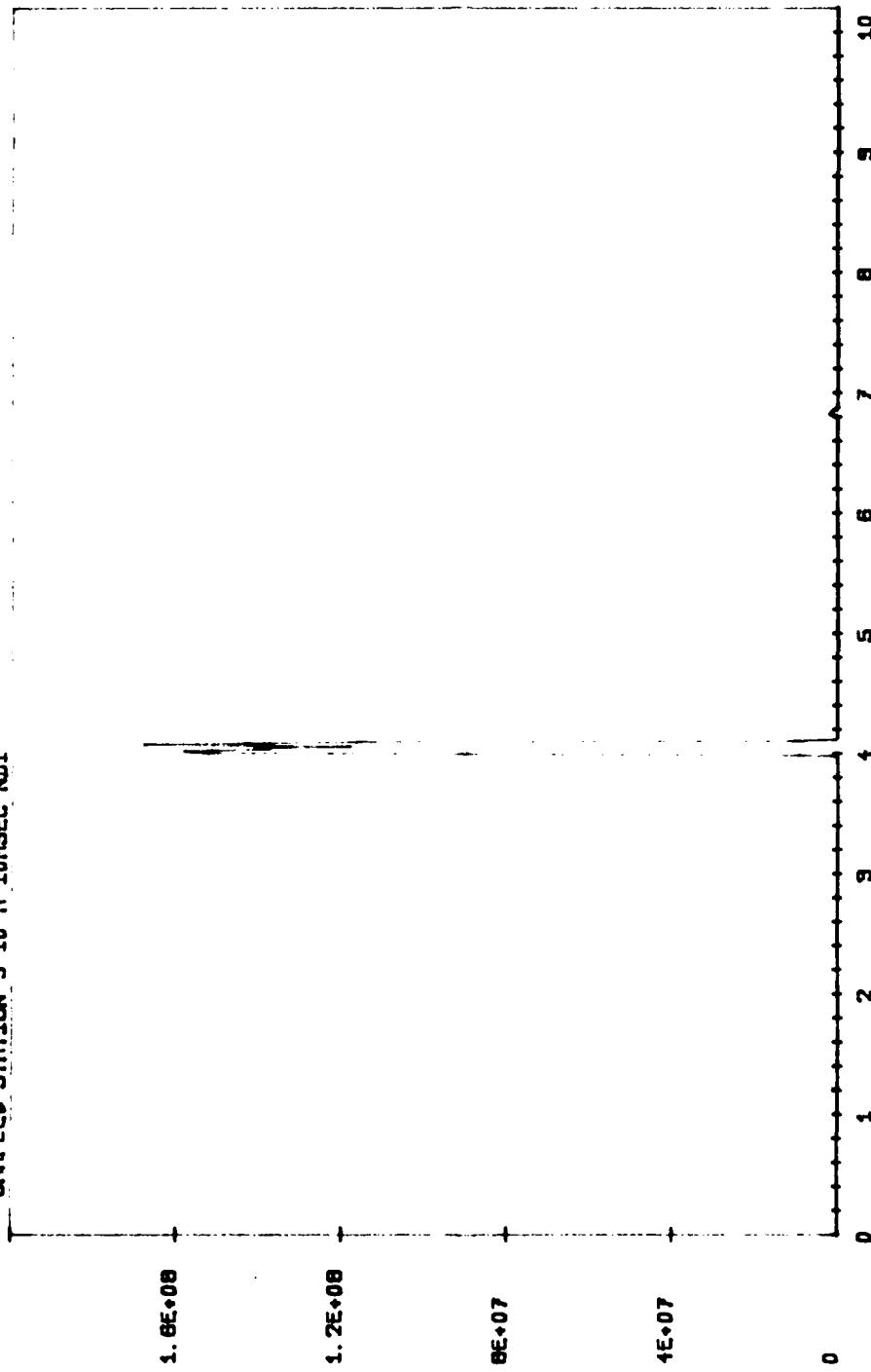
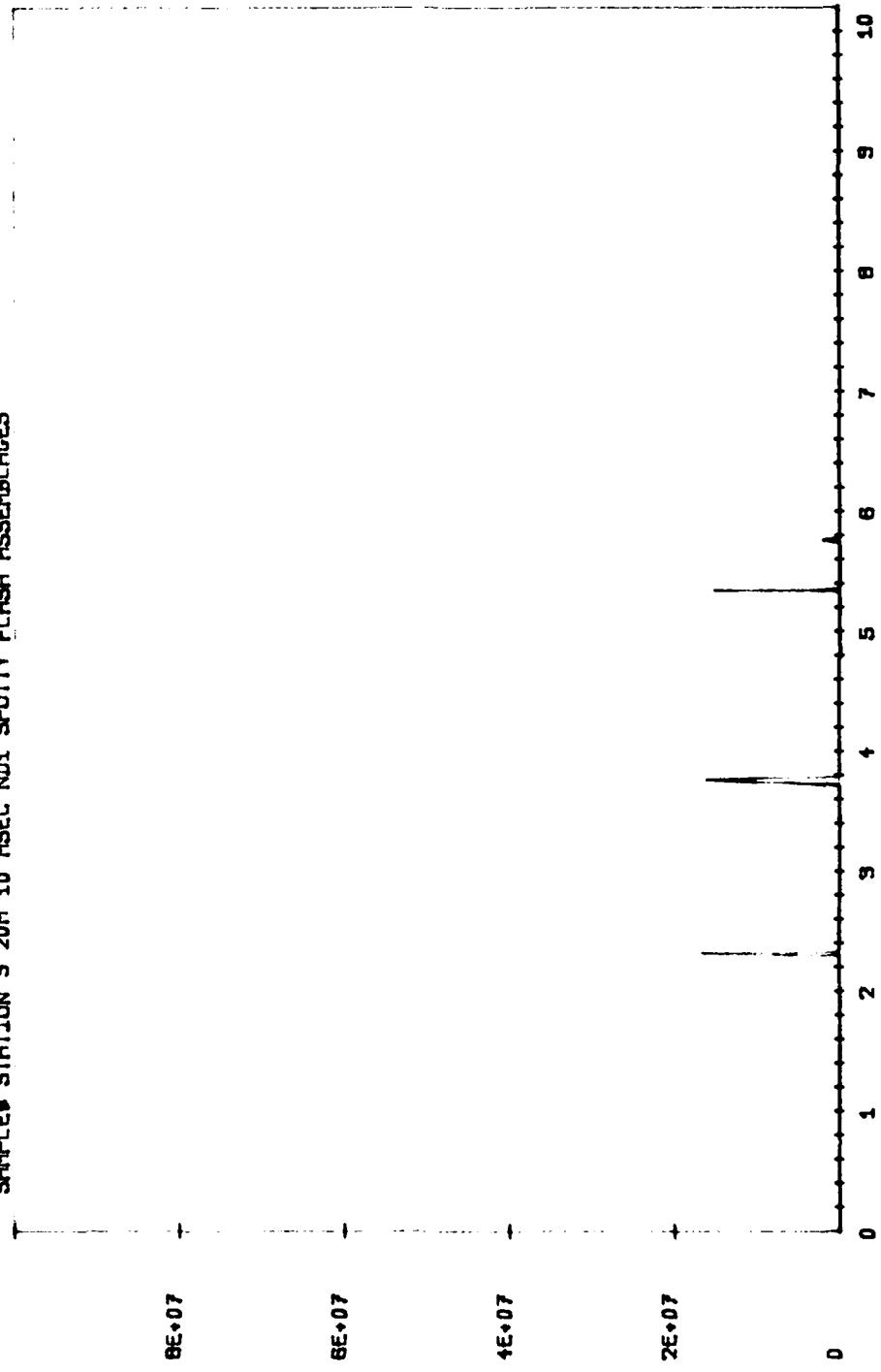


Figure B-2

09/26/86 09:20:39 BB ////ND2/ND2/ND1/D

SAMPLE# STATION# 20M 10 MSEC ND1 SPOTTY FLASH ASSEMBLAGES



B-4

Figure B-3

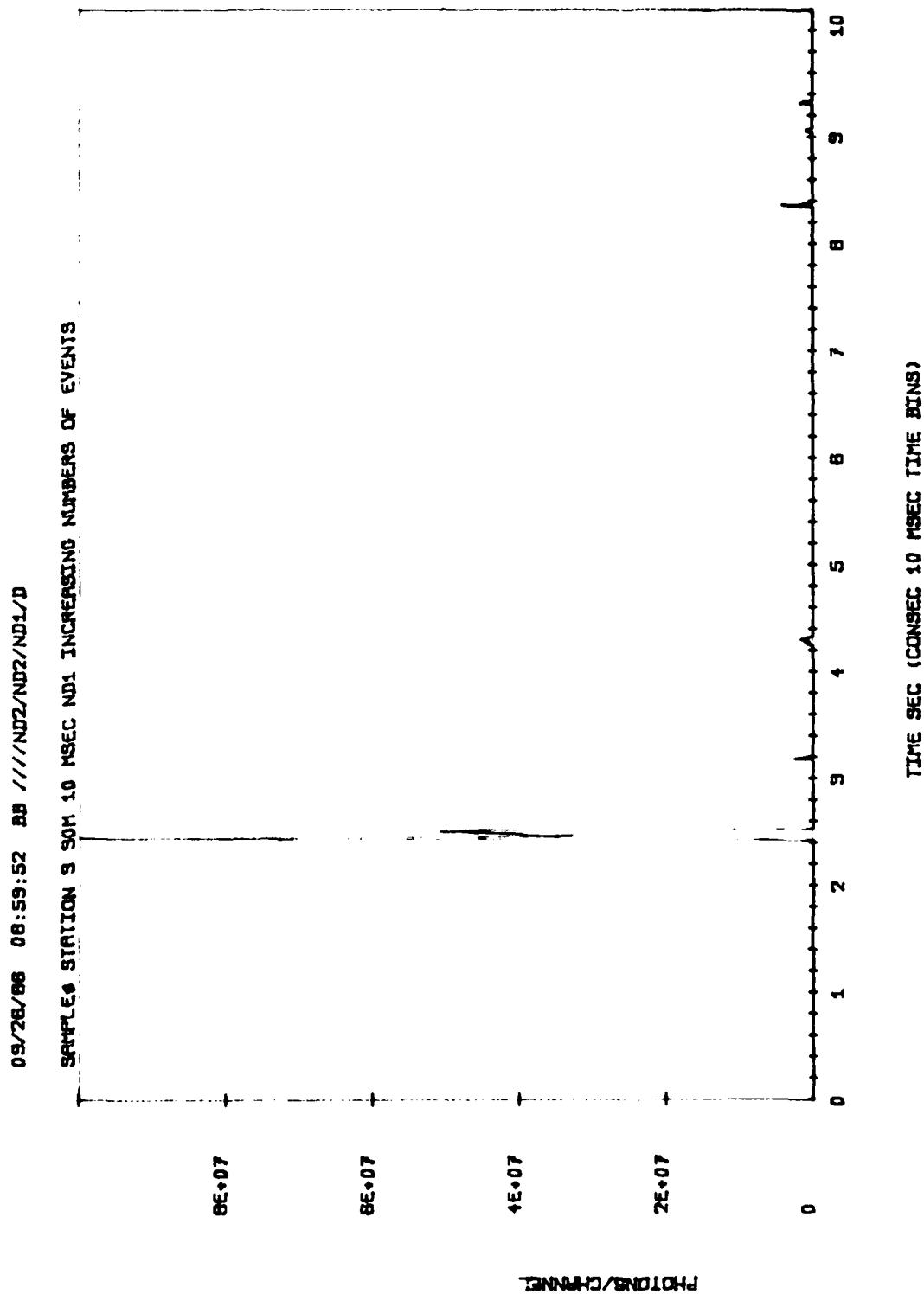


Figure B-4

09/28/86 08:44:43 BB ////ND2/ND2/ND1/D

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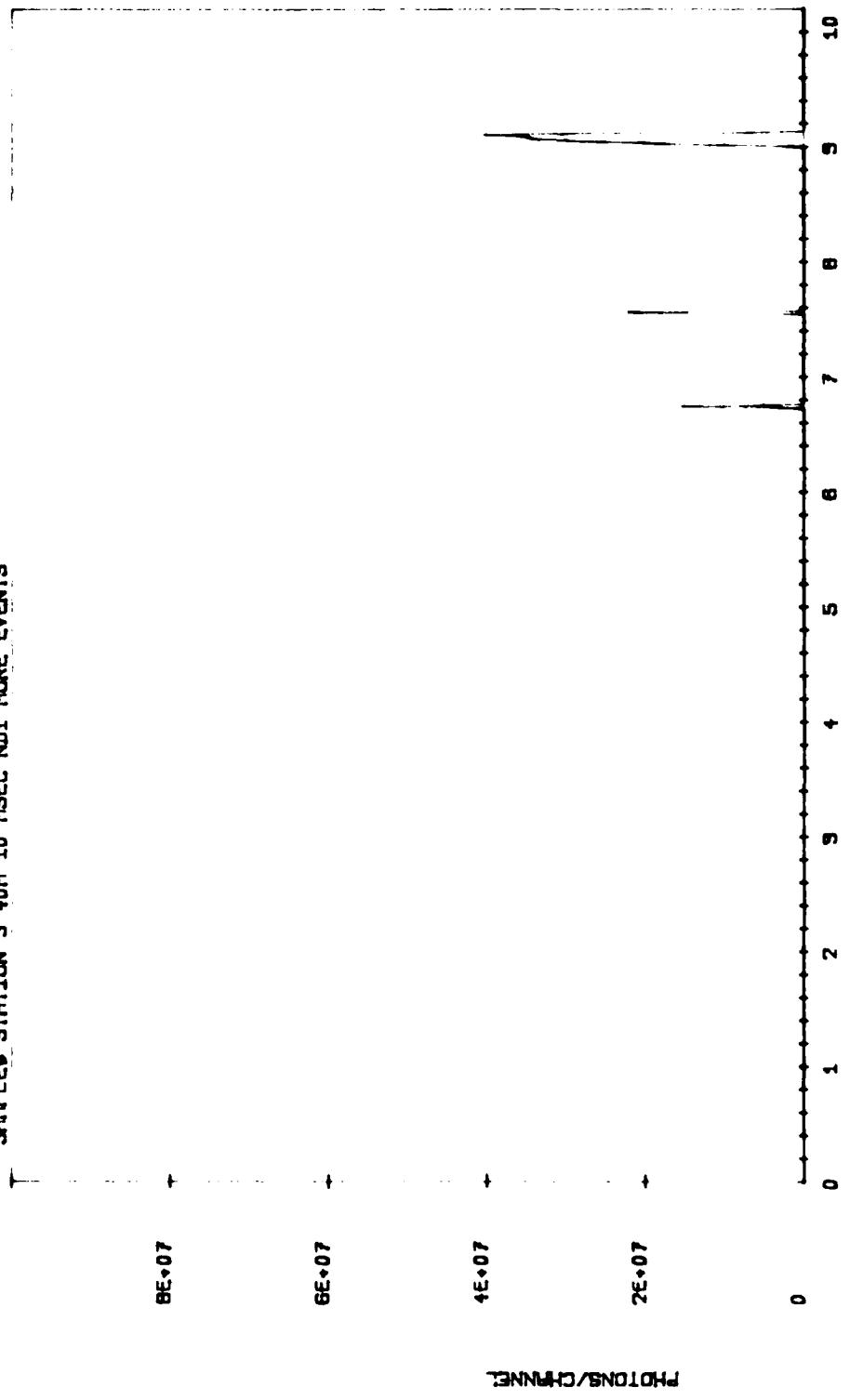
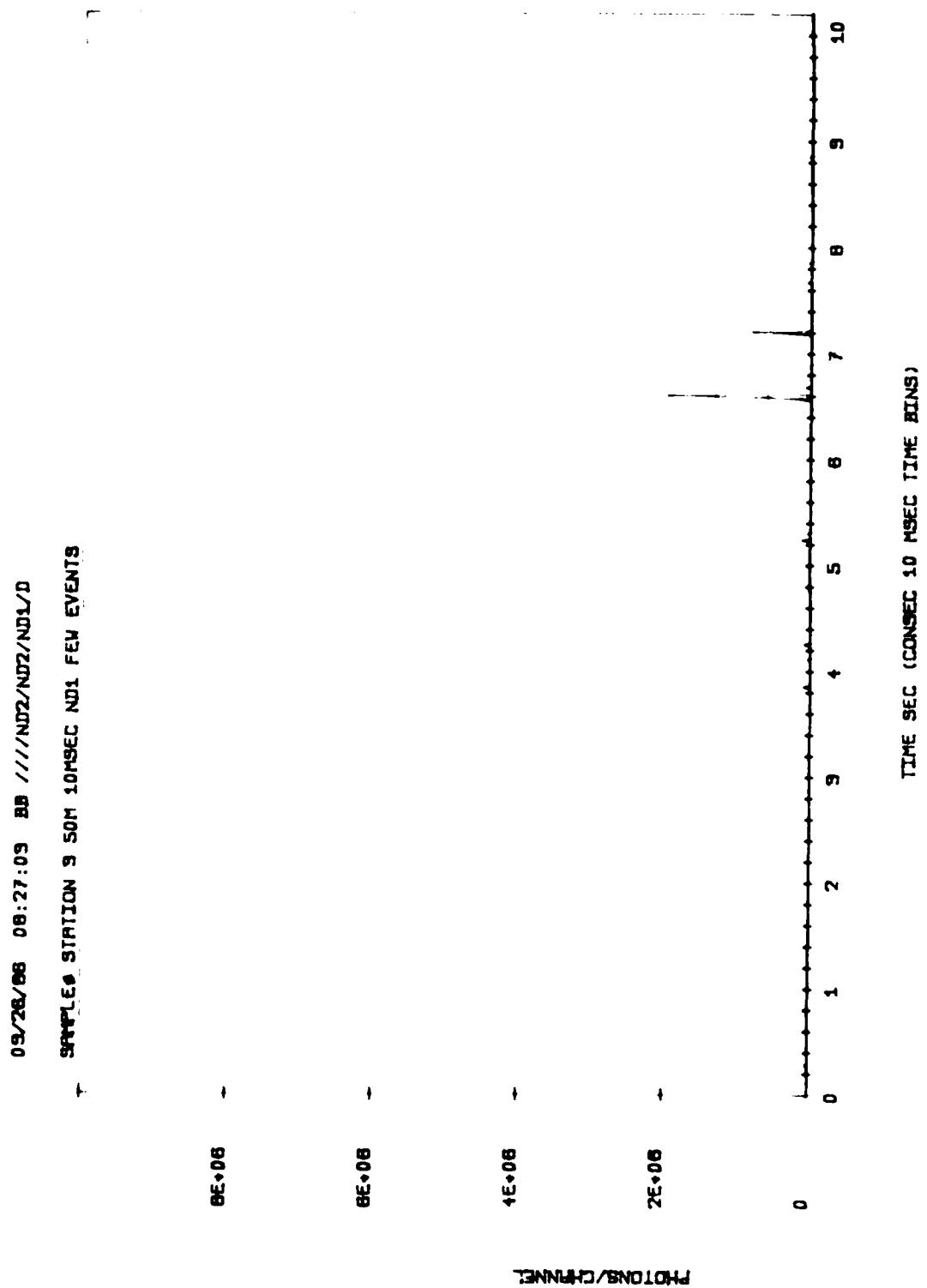


Figure B-5



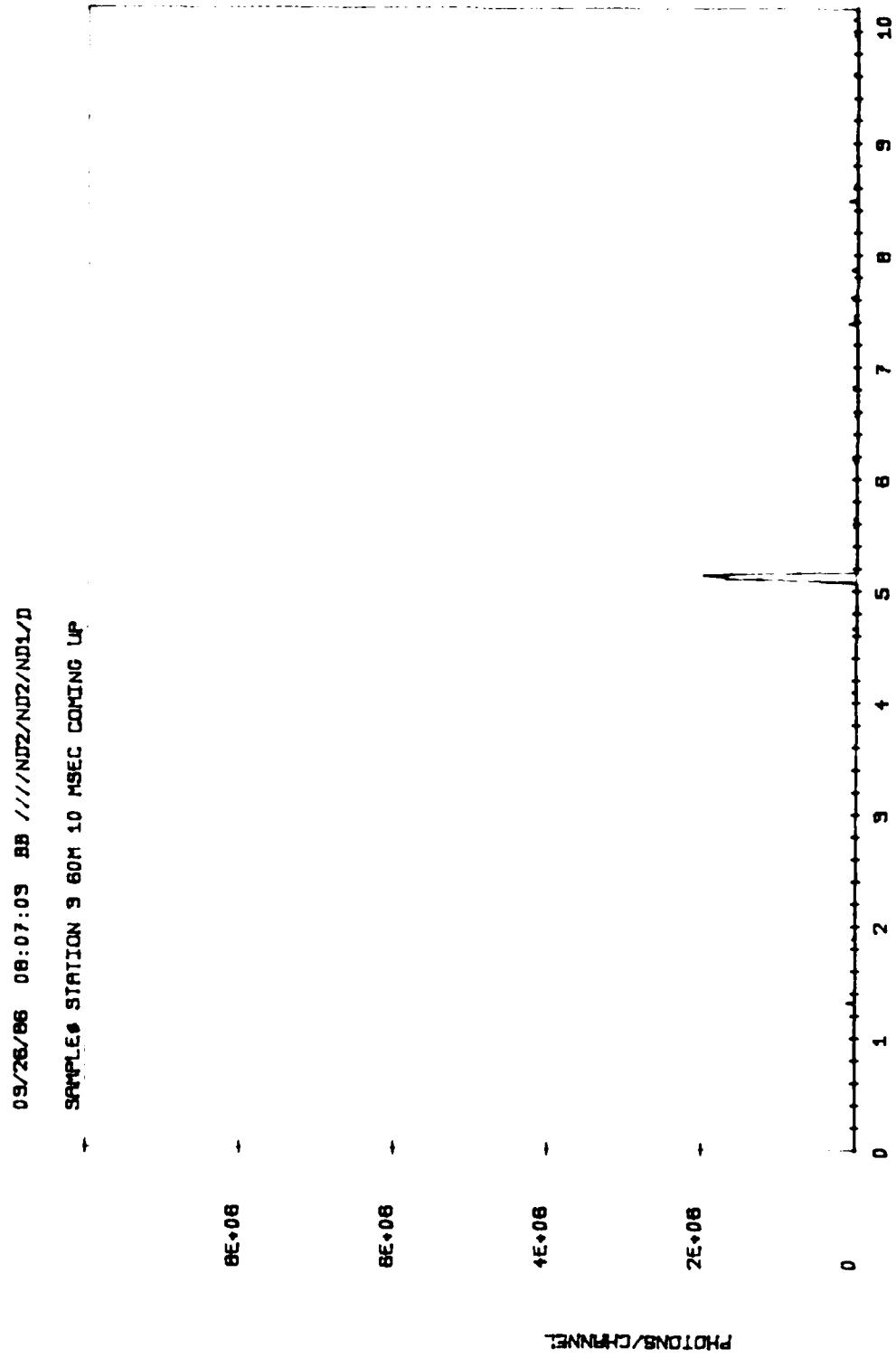


Figure B-7

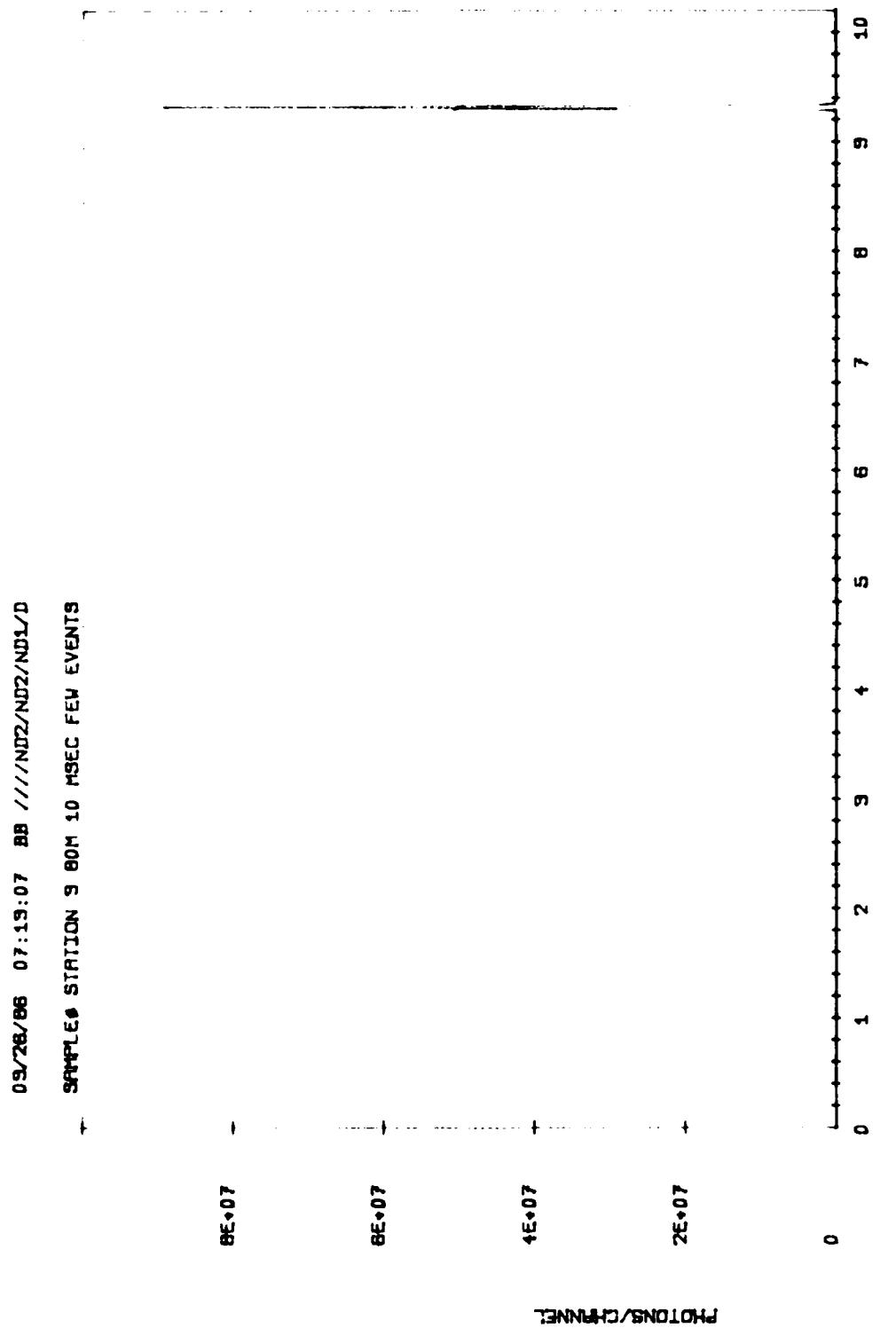


Figure B-8

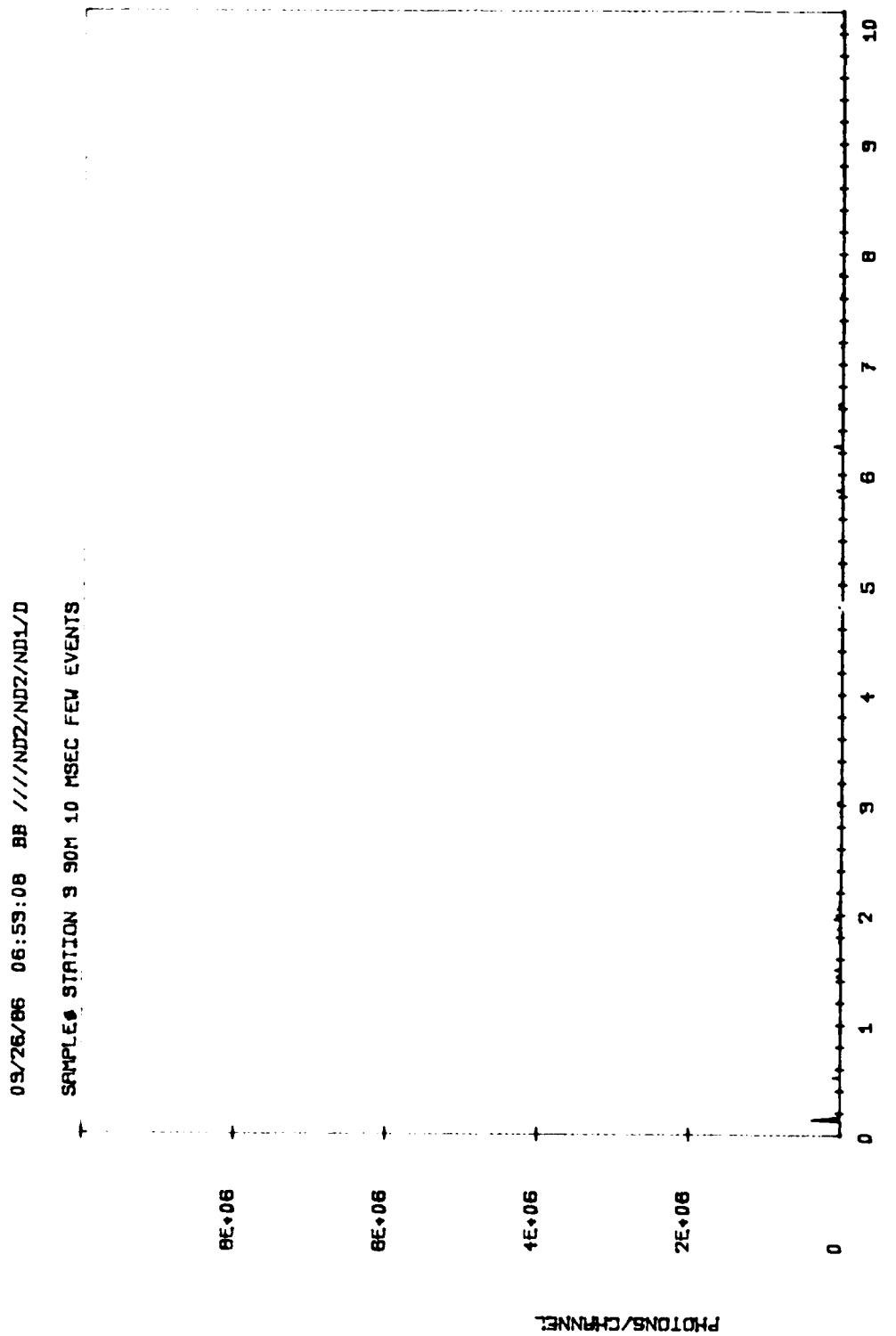


Figure B-9

03/26/86 06:35:40 BB ////ND2/ND2/ND1/D

SAMPLE# STATION 3 99M 10 MSEC FEW EVENTS

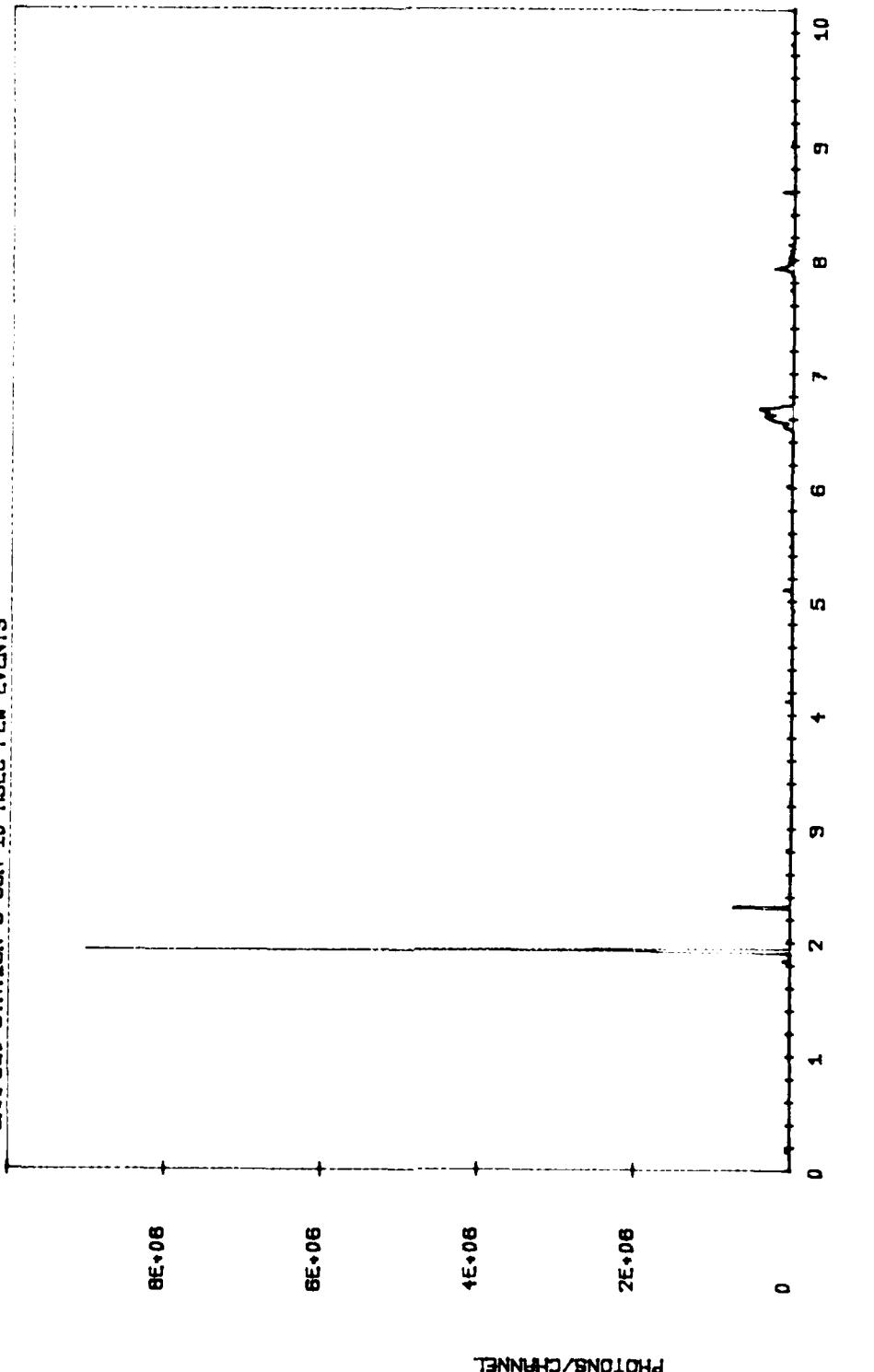


Figure B-10

09/27/88 08:12:32 BB ////ND2/ND2/ND1/D
SAMPLES STATION 4 2M 10MSEC ND1 FEW EVENTS

4E+06

3E+06

2E+06

1E+06

PHOTONS/CHANNEL

B-12

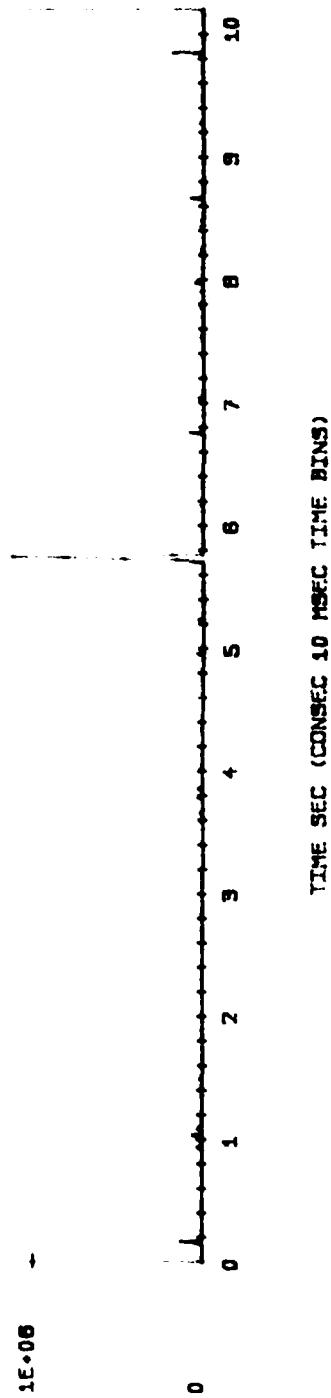
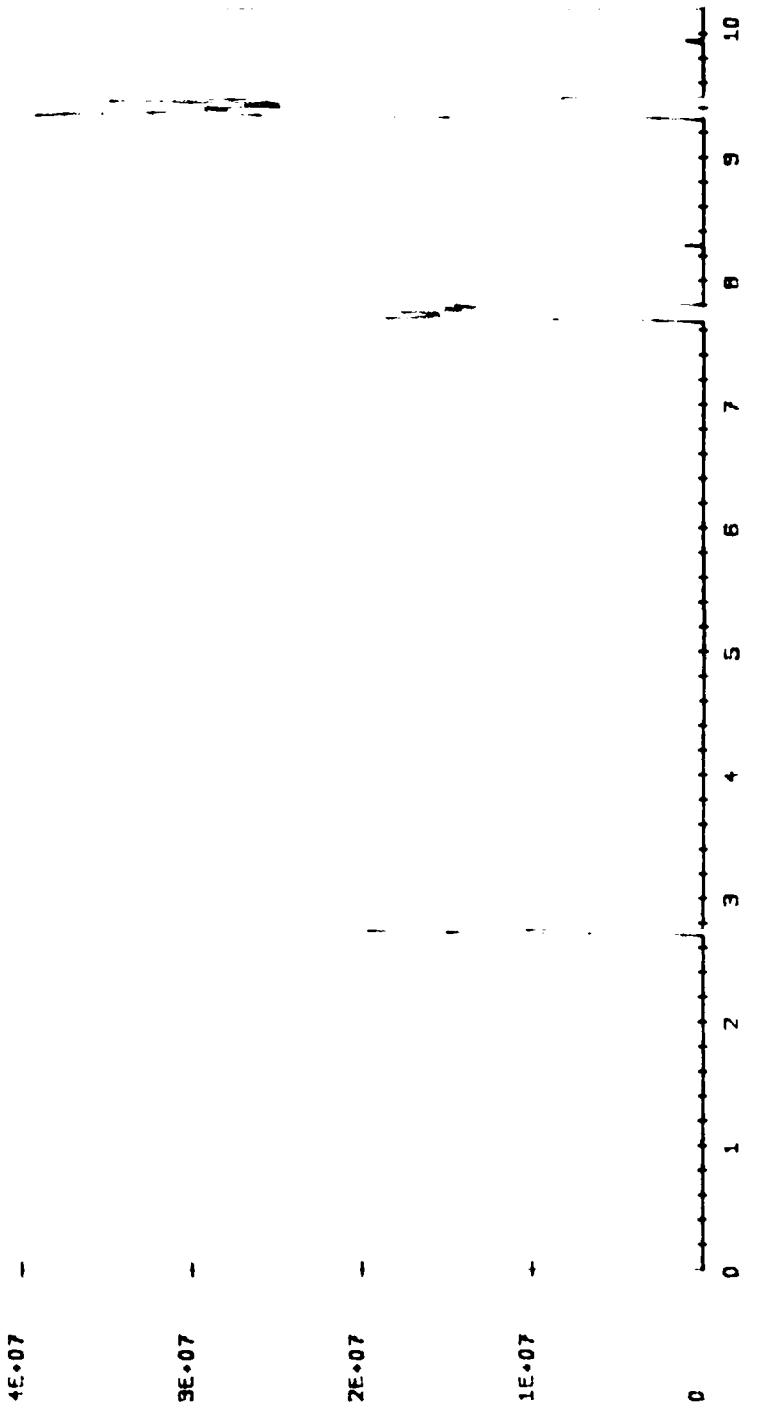


Figure B-11

09/27/86 08:02:58 BB ////ND2/ND2/ND1/D
SAMPLE STATION + 10M 10MSEC ND1 MORE EVENTS



B-13

Figure B-12

09/27/66 07:48:51 BB //ND2/ND2/ND1/D
SAMPLES STATION 4 20M ND1 10MSEC MORE EVENTS

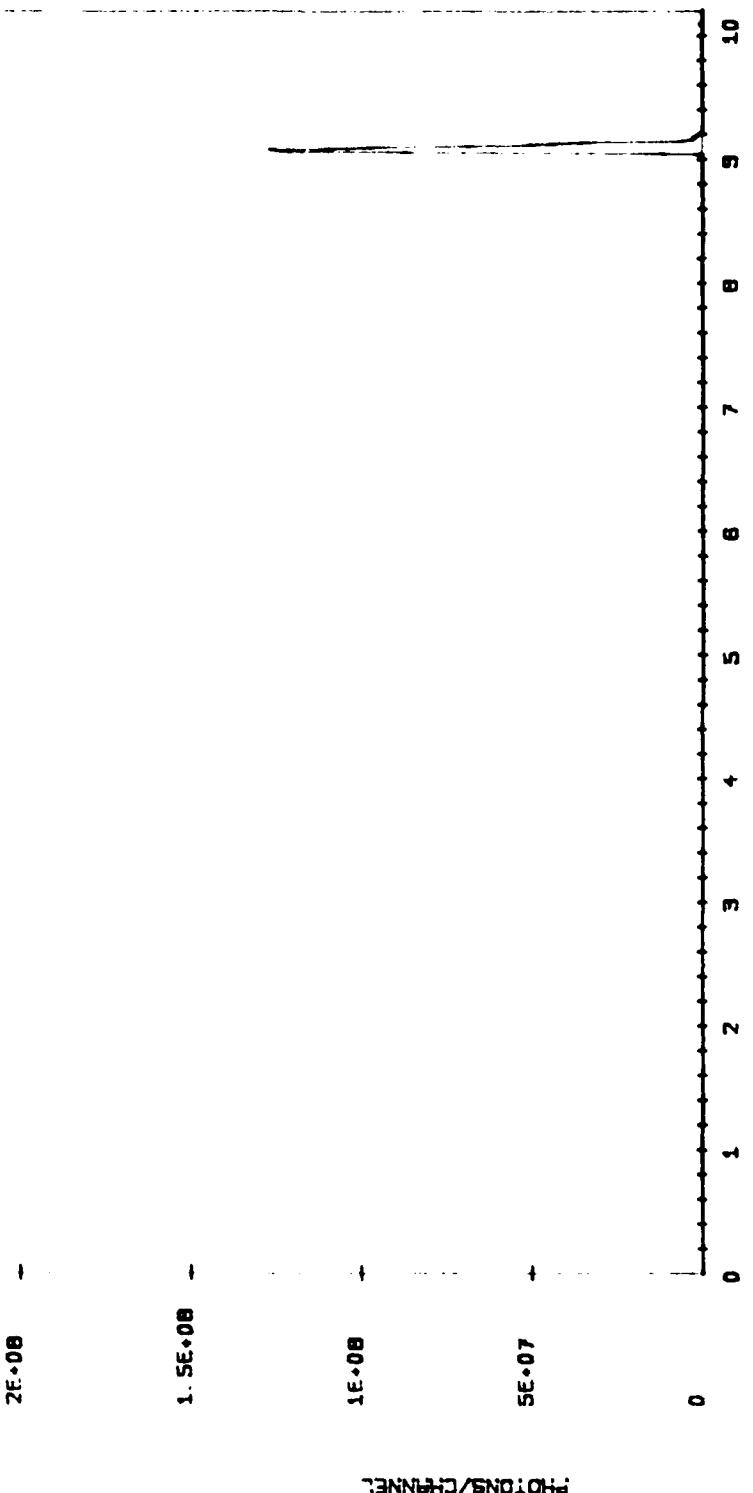


Figure B-13

09/27/88 07:42:34 BB ////ND2/ND2/ND1/D

SAMPLE# STATION 4 90M 10MSEC ND1 FEW MORE EVENTS

4E+07

3E+07

2E+07

1E+07

PHOTONS/CHANNEL

B-15

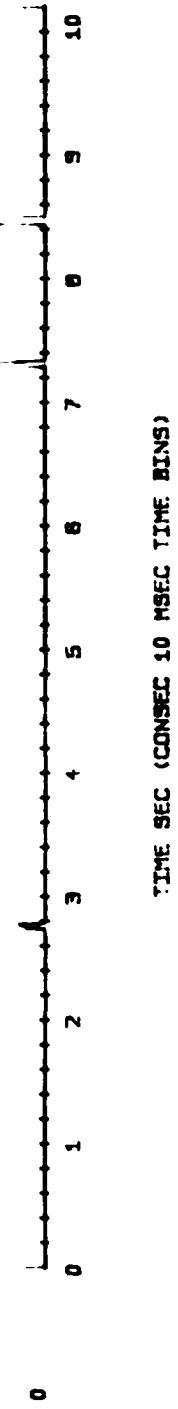


Figure B-14

09/27/86 07:35 48 BB ////ND2/ND2/ND1/D
SAMPLES STATION 4 40M ND1 10MSEC FEW EVENTS

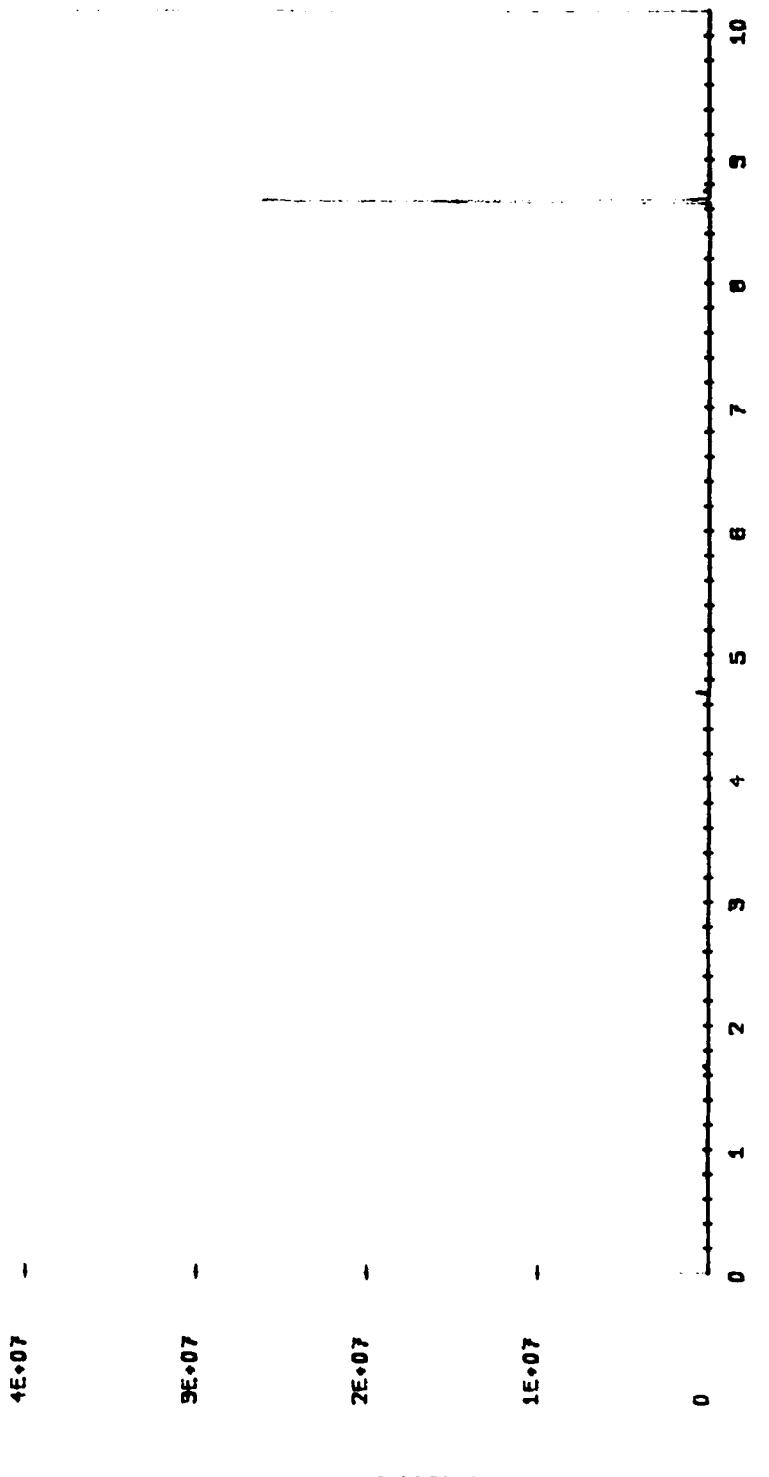


Figure B-15

09/27/88 07:28:24 BB ////ND2/ND2/ND1/D

SAMPLE STATION 4 50M 10MSEC ND1 FEV EVENTS

800000

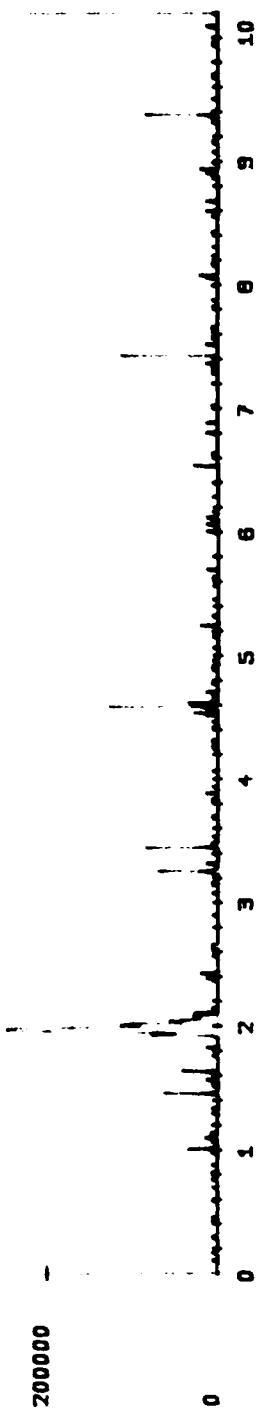
600000

400000

200000

PHOTONS/CHANNEL

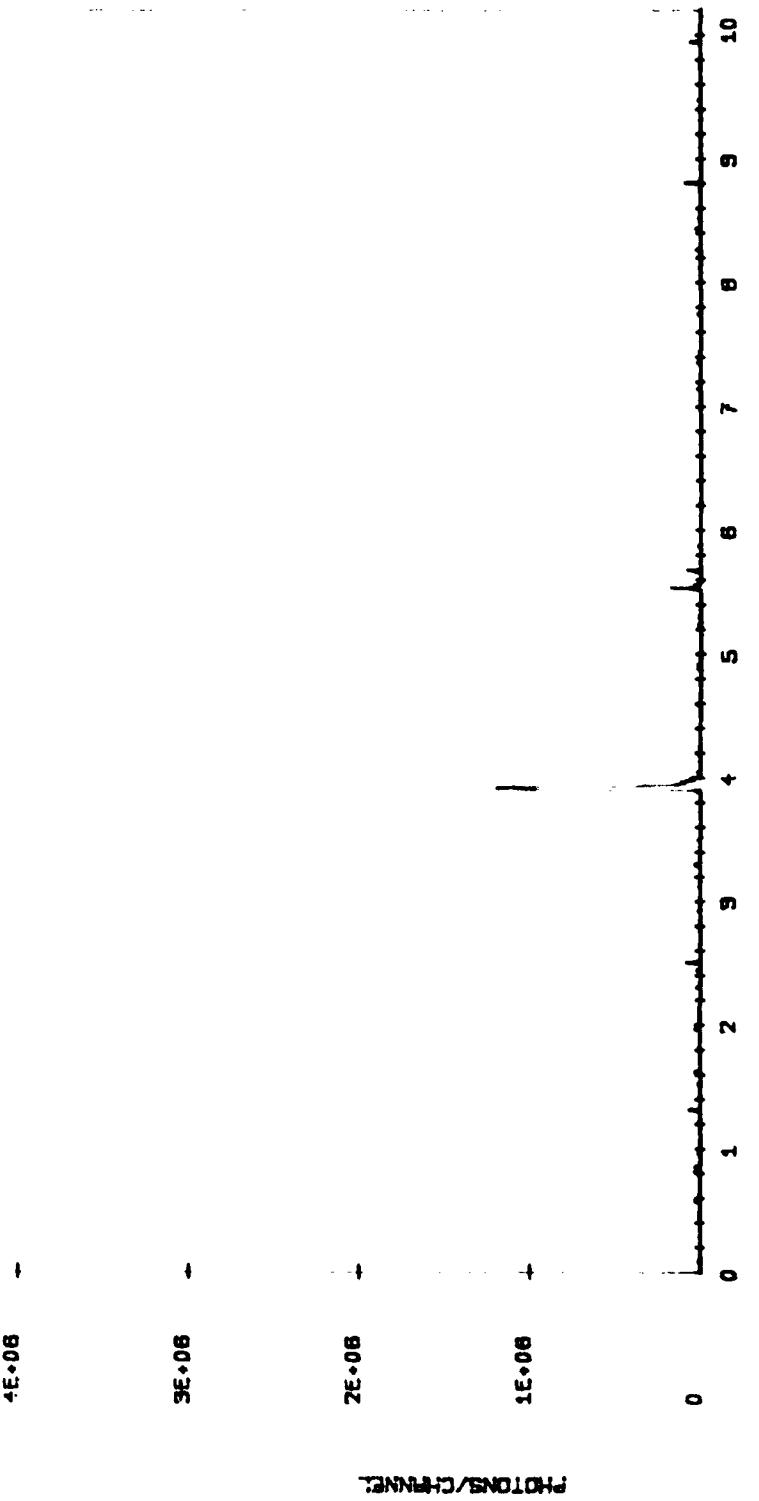
B-17



TIME SEC (CONSEC 10 NSEC TIME BINS)

Figure B-16

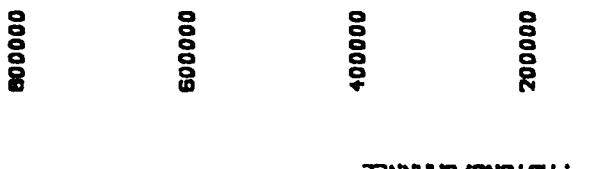
09/27/88 07:22:55 BB ////ND2/ND2/ND1/D
SAMPLE STATION 4 60M 10MSEC ND1 FEW EVENTS



TIME SEC (CONSEC 10 MSEC TIME BINS)

Figure B-17

09/27/68 07:07:06 BB ////ND1/ND2/ND2/ND1/D
SAMPLES STATION 4 COMING UP 75M 10MSEC ND1 FEW EVENTS



B-19

TIME SEC (CONSEC 10 SEC TIME BINS)

Figure B-18

09/27/88 06:52:15 BB ////ND2/ND2/ND1/D
SAMPLE STATION 4 82m 10msec ND1 FEW EVENTS

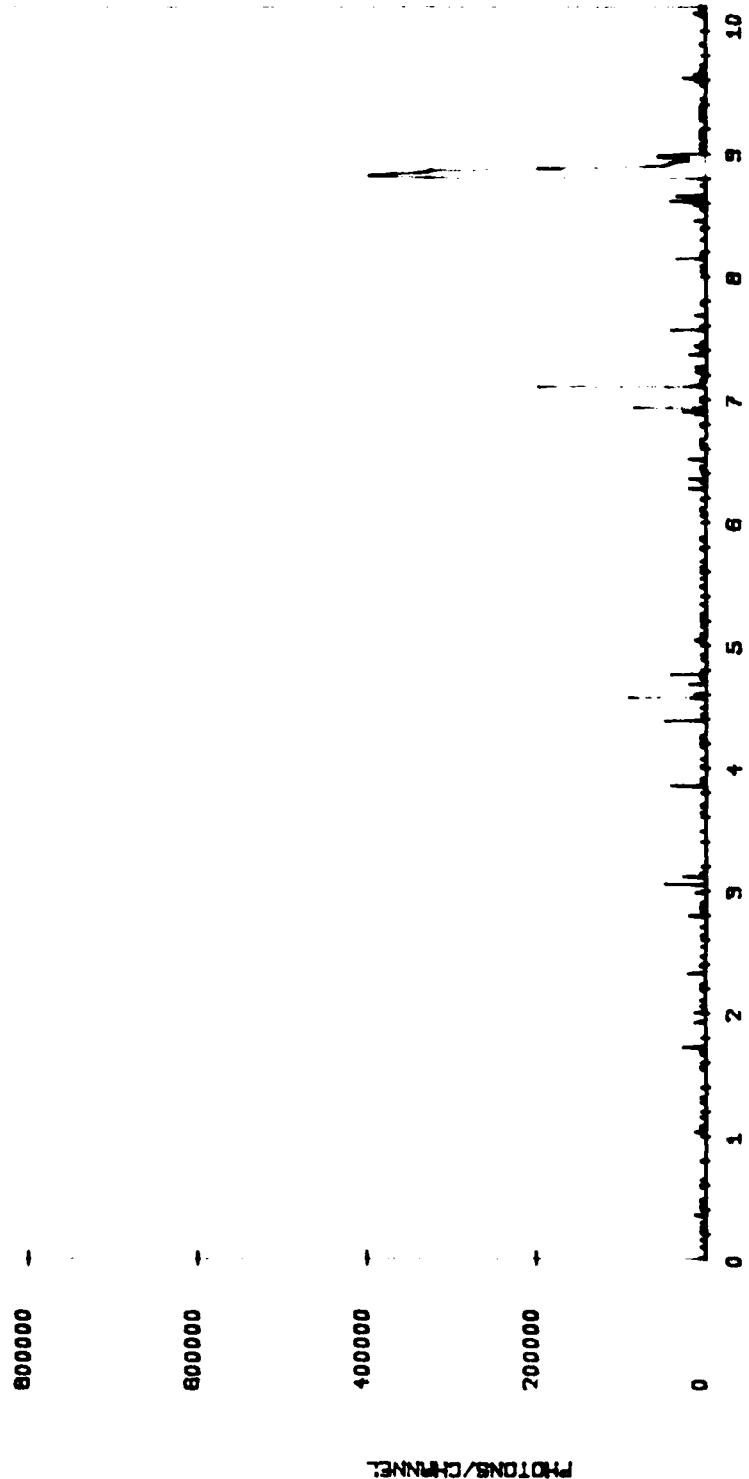


Figure B-19

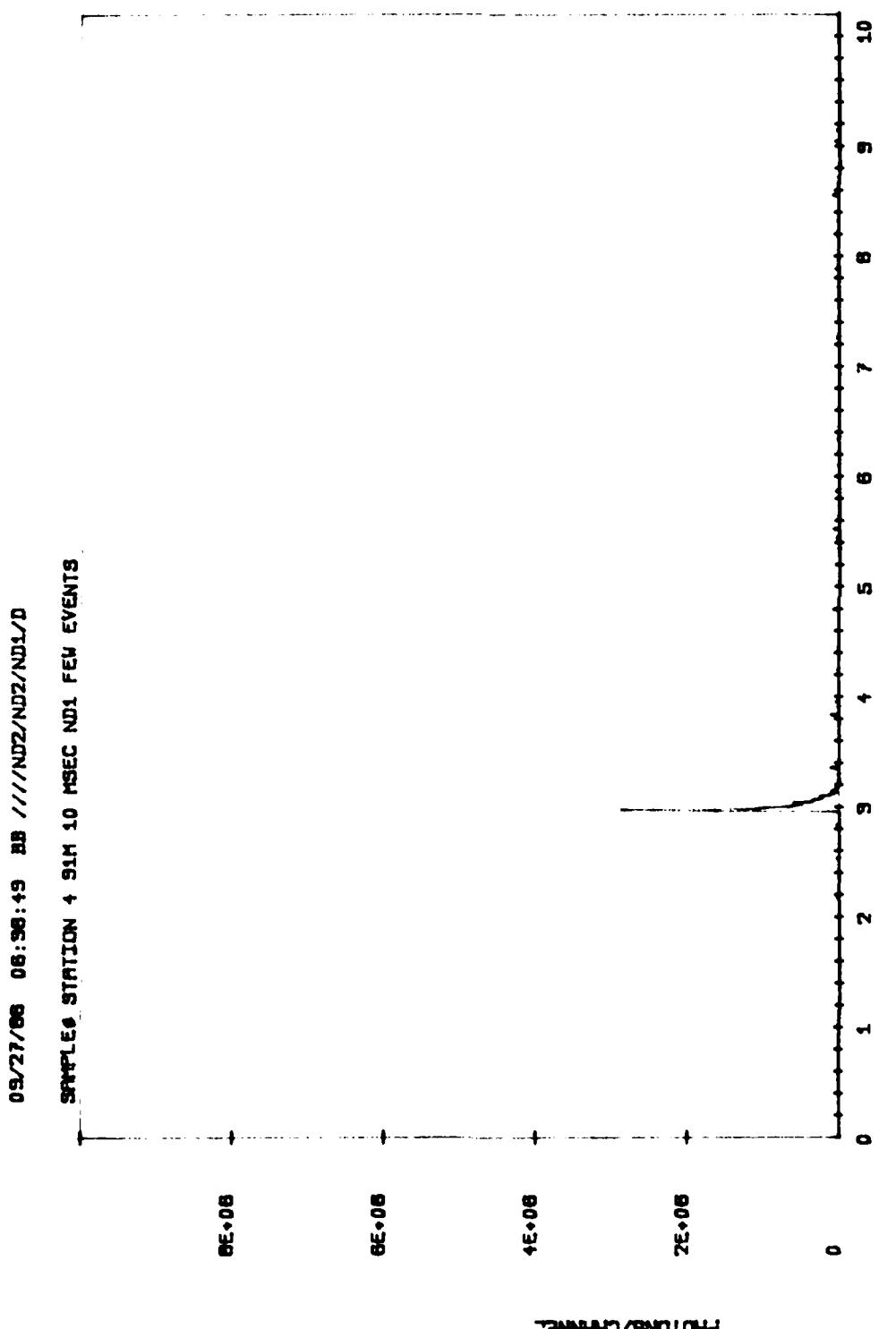
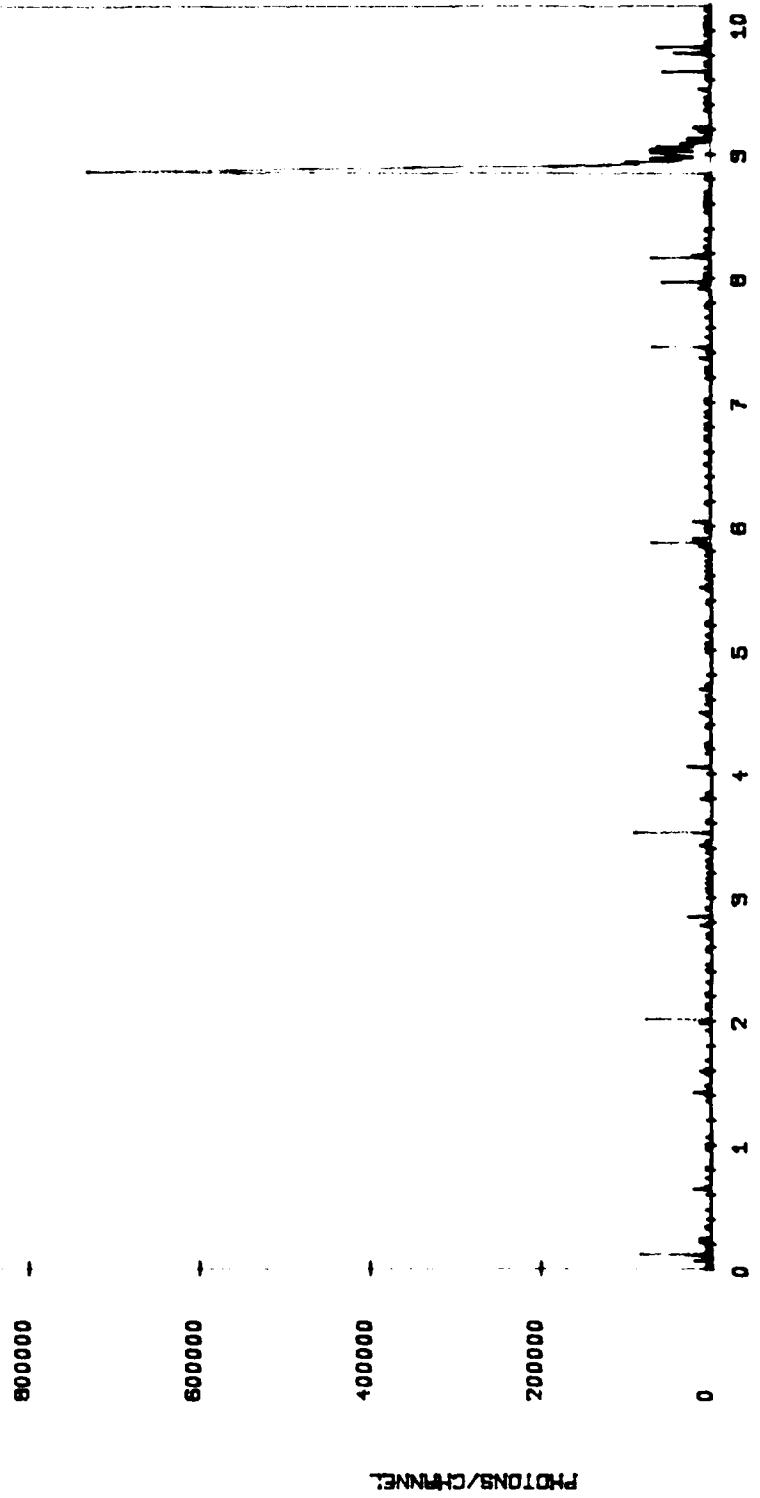


Figure B-20

09/27/86 06:26:38 BB ////ND2/ND2/ND1/D
SAMPLE STATION 4 100M 10MSEC ND1 FEW EVENTS



B-22

Figure B-21

09/29/66 08.44.38 88 //77/ND2/ND2/ND2/ND2

SAMPLE STATION 5 4H 10 SEC NDI

T

4E+08

3E+08

2E+08

1E+08

0

PHOTON/CHANNEL

B-23

TIME SEC (CONSEC 10 SEC TIME BINS)

Figure B-22

05/29/68 08 23 51 33 //V02/V07/V01/D
SAMPLE STATION 5 101 10:56C V01 101 101/Y

4F-08 -

3F-08 -

PHOTONS/CHANNEL

B-24



TIME SEC (CONSEC 10 SEC TIME BINS)

Figure B-23

09/29/68 08.08.38 BB //ND2/ND2/ND2

SAMPLES STATION 5 20M 10SEC NDI HEAVIEST NUMBERS OF EVENTS OBSERVED

4E+08

-

3E+08

-

2E+08

-

1E+08

-

PHOTONS/CHANNEL



TIME SEC (CONSEC 10 SEC SEC TIME BIN)

Figure B-24

09/29/86 07 27 52 BB ////ND2/ND2/ND1/ND1

- SAMPLE STATION S 281 10MSEC ND1 GREATEST NUMBER OF EVENTS YET

4E+08

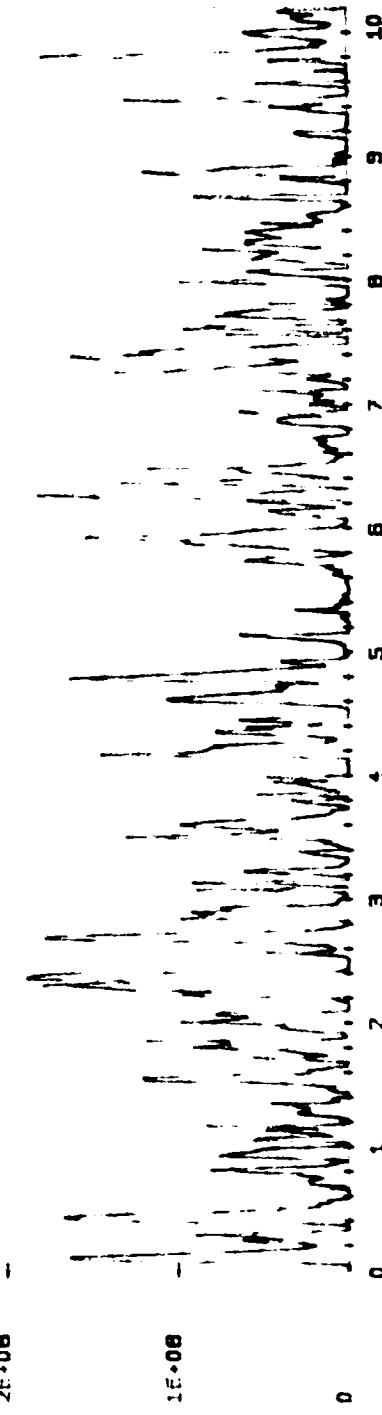
3E+08

PHOTONS/CHANNEL

-

2E+08

-



TIME SEC (CONSEC 10 MSEC TIME BINS)

Figure B-25

09/29/68 07 07 14 BB //ND2/ND2/ND1/D
SAMPLE STATION 5 8:30 10:30:5C ND1 INCREASING NUMBERS OF EVENTS

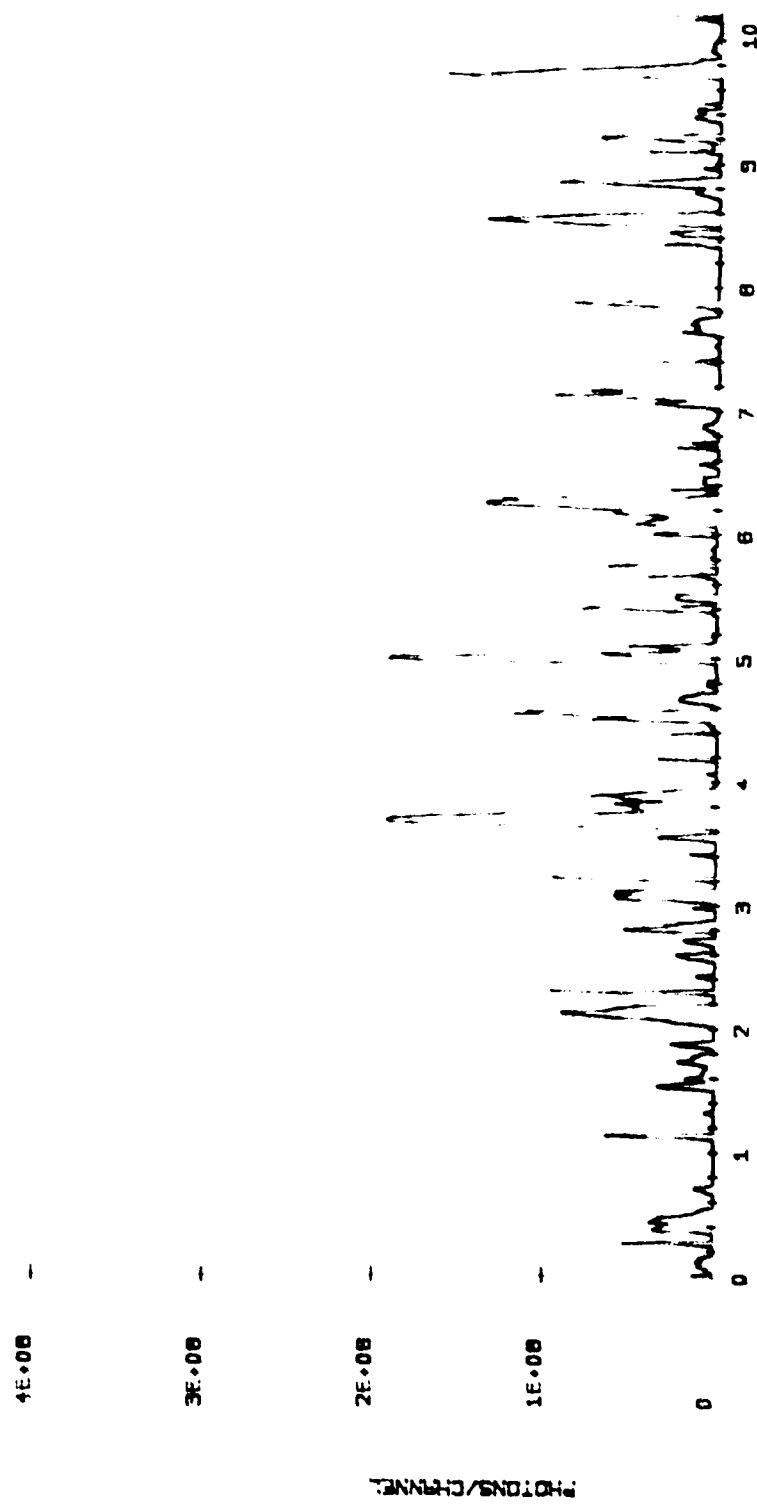


Figure B-26

09/29/86 06:55:14 BB //ND2/ND2/ND1/0
SAMPLE STATION 5 40m 10msec ND1 DOTS OF EVENTS

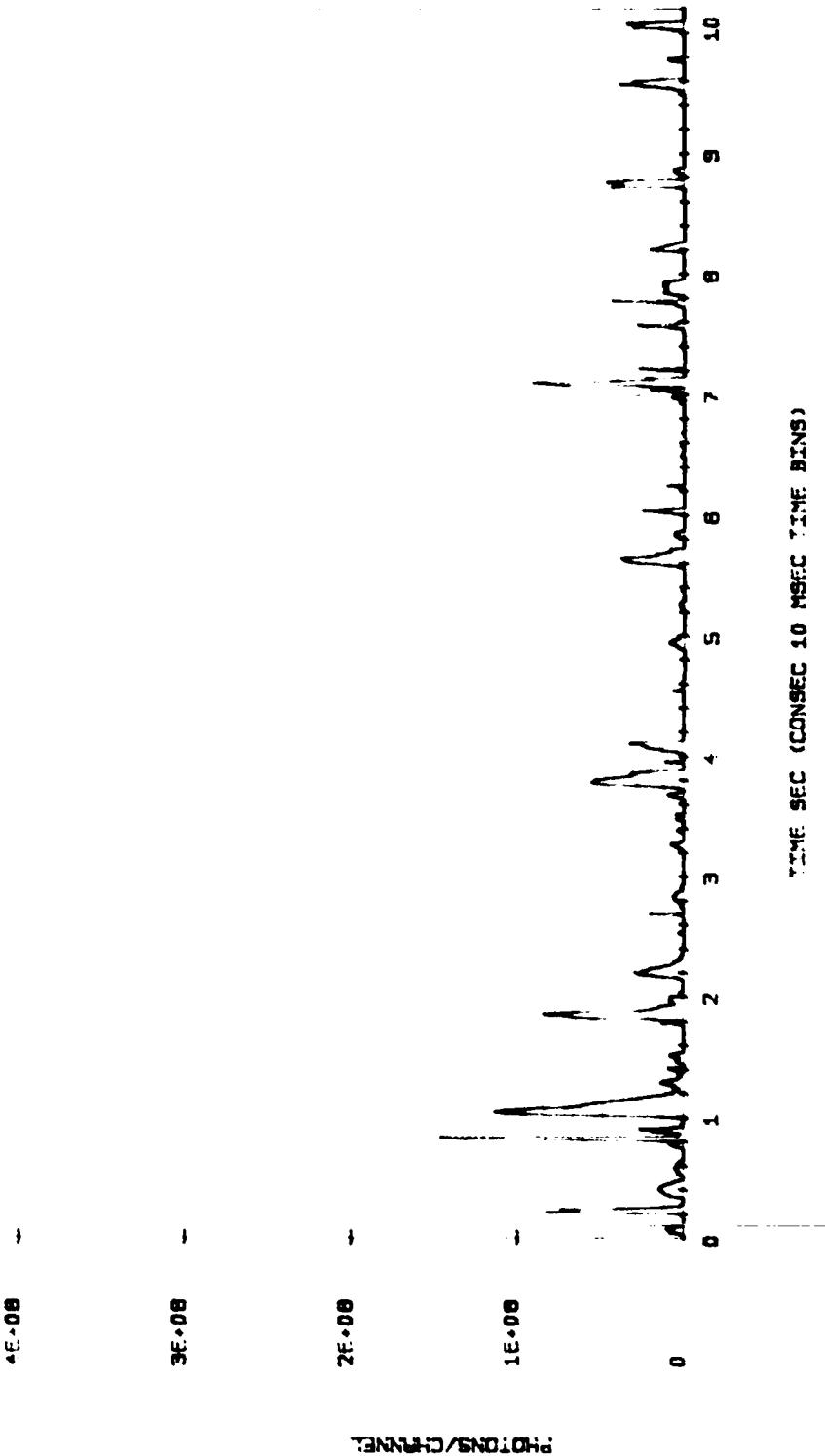


Figure B-27

09/23/88 06:43:16 B.B //ND2//ND2//ND2//

SAMPLES STATION 5 601 10:SEC ND1 FEVER EVENTS

4E+08 -

3E+08 -

2E+08 -

1E+08 -

PHOTON/CHANNEL

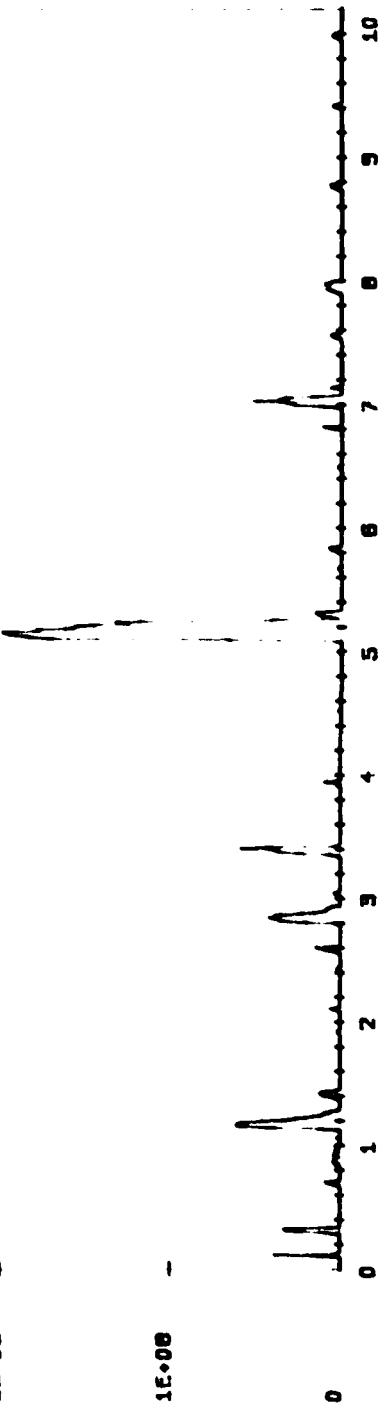


Figure B-28

09/29/08 08:33:02 BB ////ND2/ND2/ND2/ND2/D

SAMPLES STATION 5 70M 10MSEC ND1 MORE EVENTS

4E+08

3E+08

2E+08

1E+08

PHOTONS/CHIRP

B-30

TIME SEC (CONSEC 10 MSEC TIME BINS)

Figure B-29

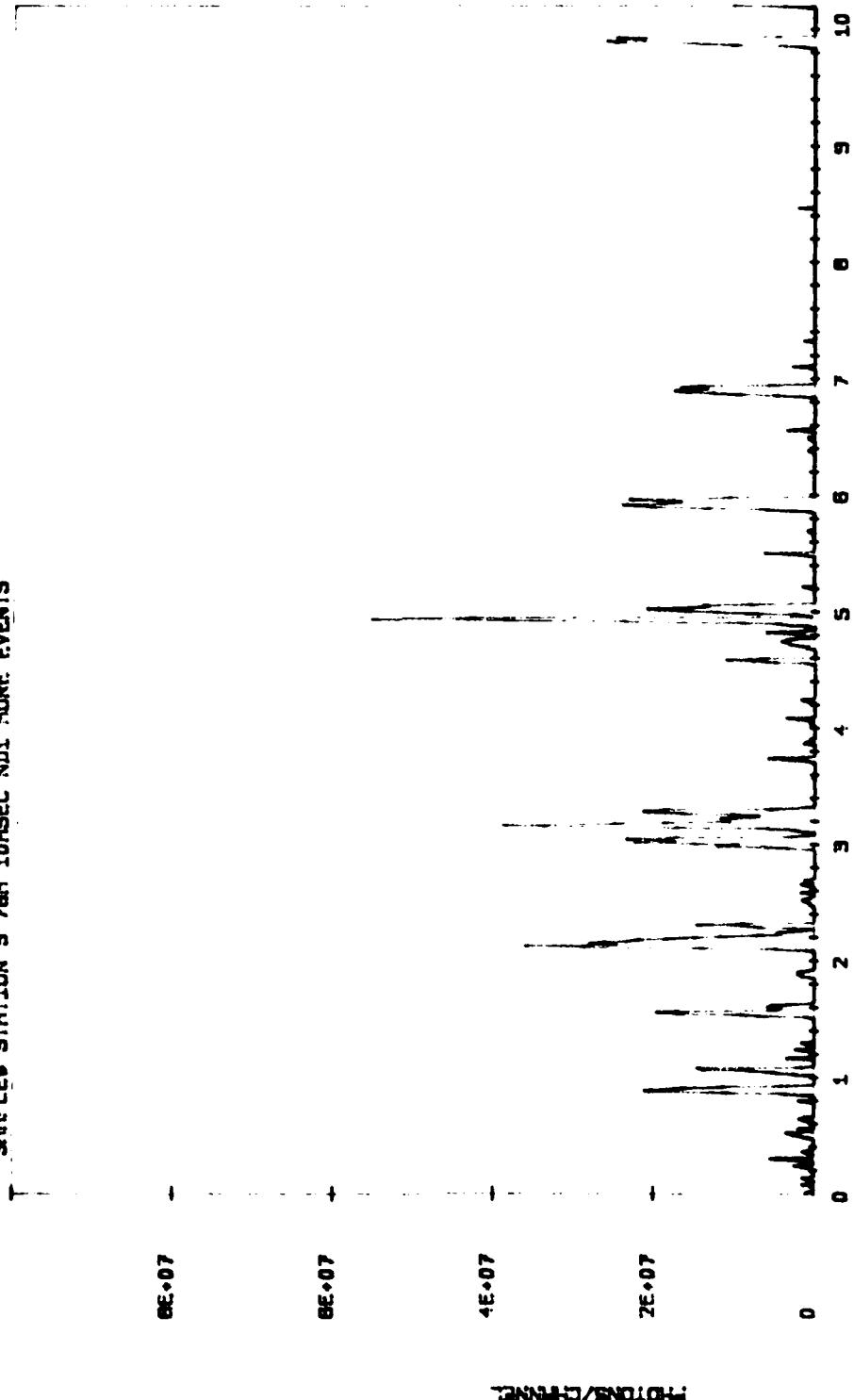


Figure B-30

TABLE OF CONTENTS

09/29/68 08:01:40 BB ////ND2/ND2/ND1/D

SAMPLES, STATION 5 91.1 10SEC. NO1. LOTS OF EVENTS

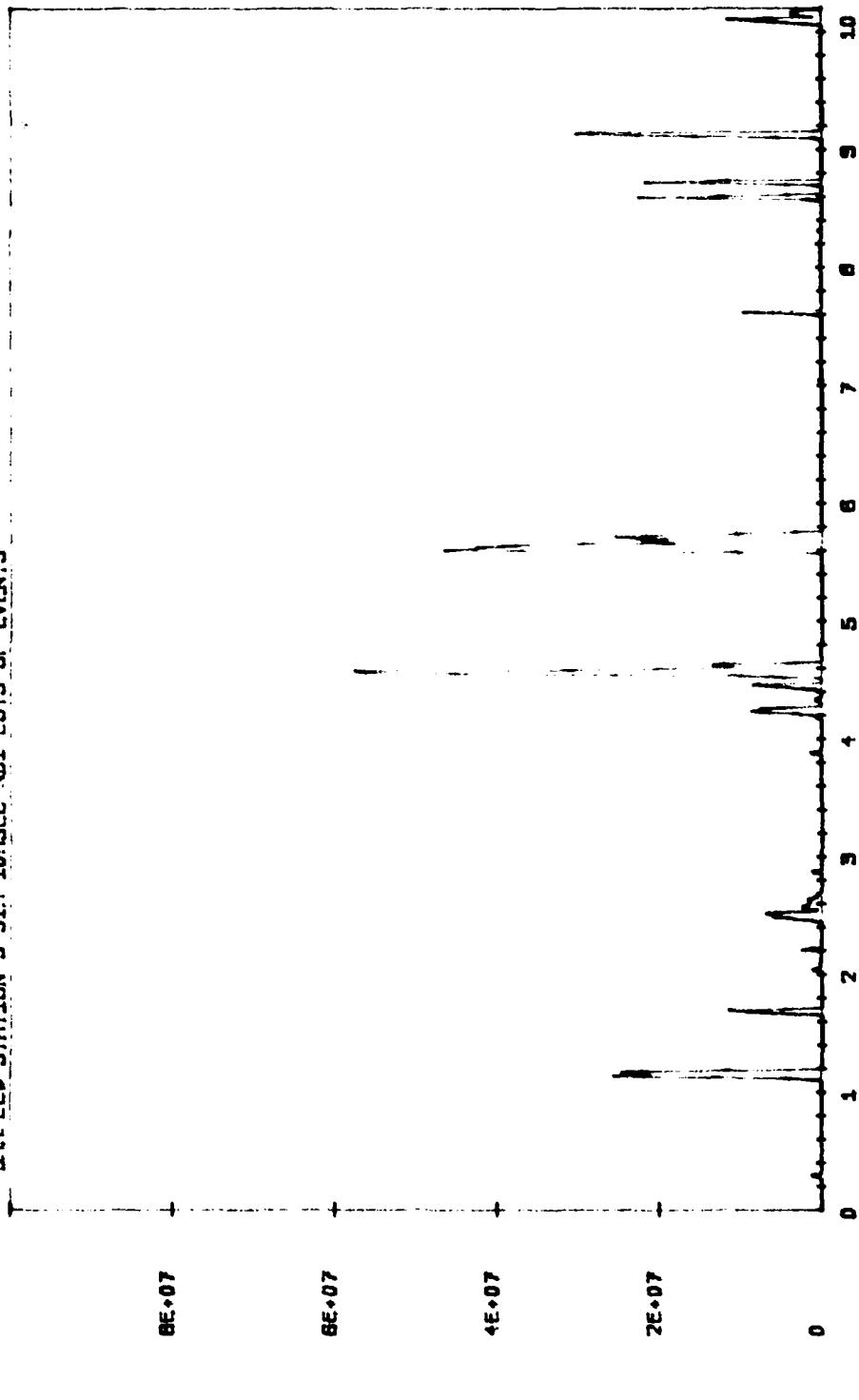


Figure B-31

APPENDIX C

HIGH TIME RESOLUTION SCANS OF BIOLUMINESCENCE FLASHES FROM
INDIVIDUAL PLANKTERS TESTED IN THE LABORATORY PLANKTON
TEST CHAMBER (LPTC)

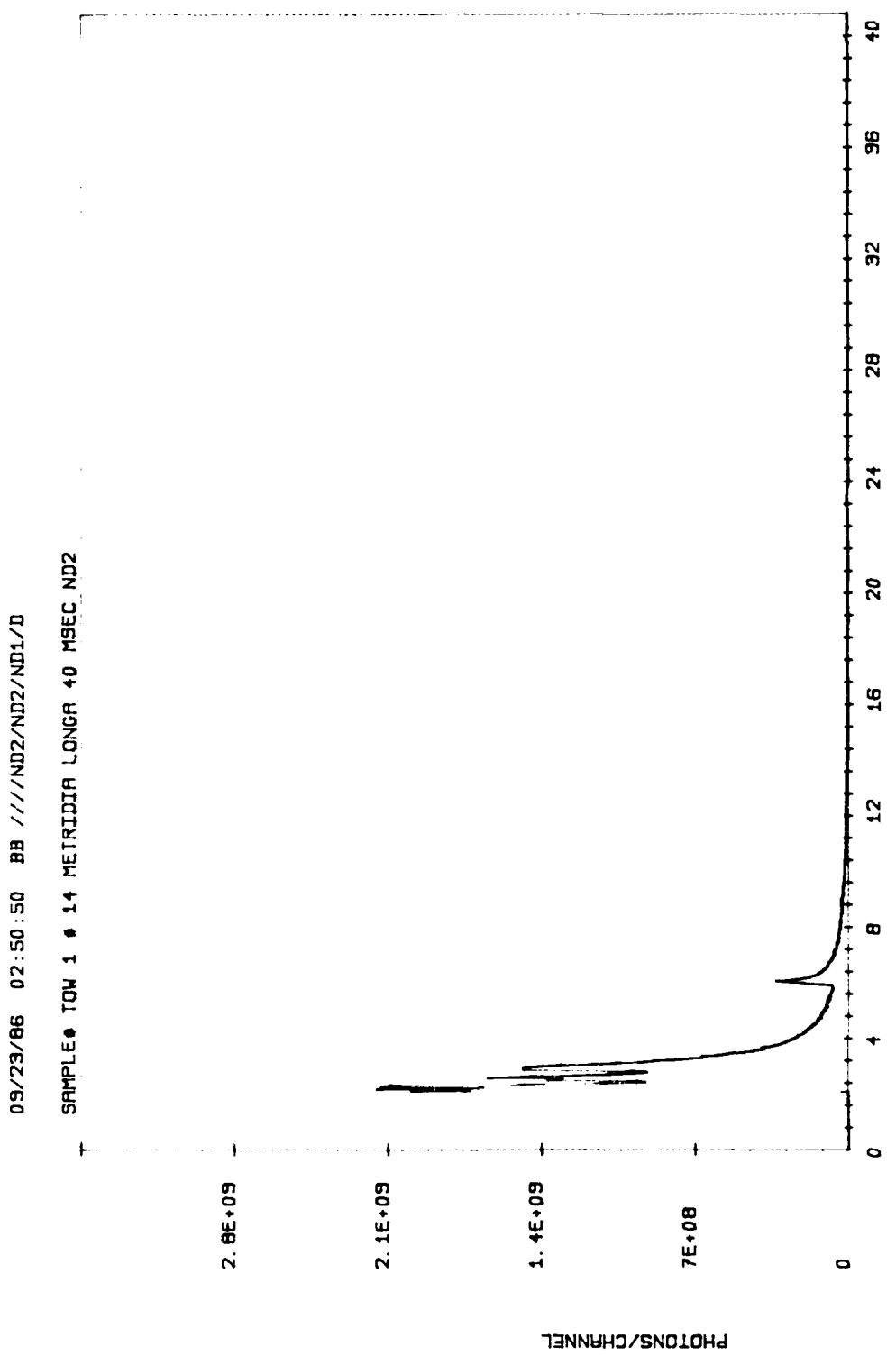
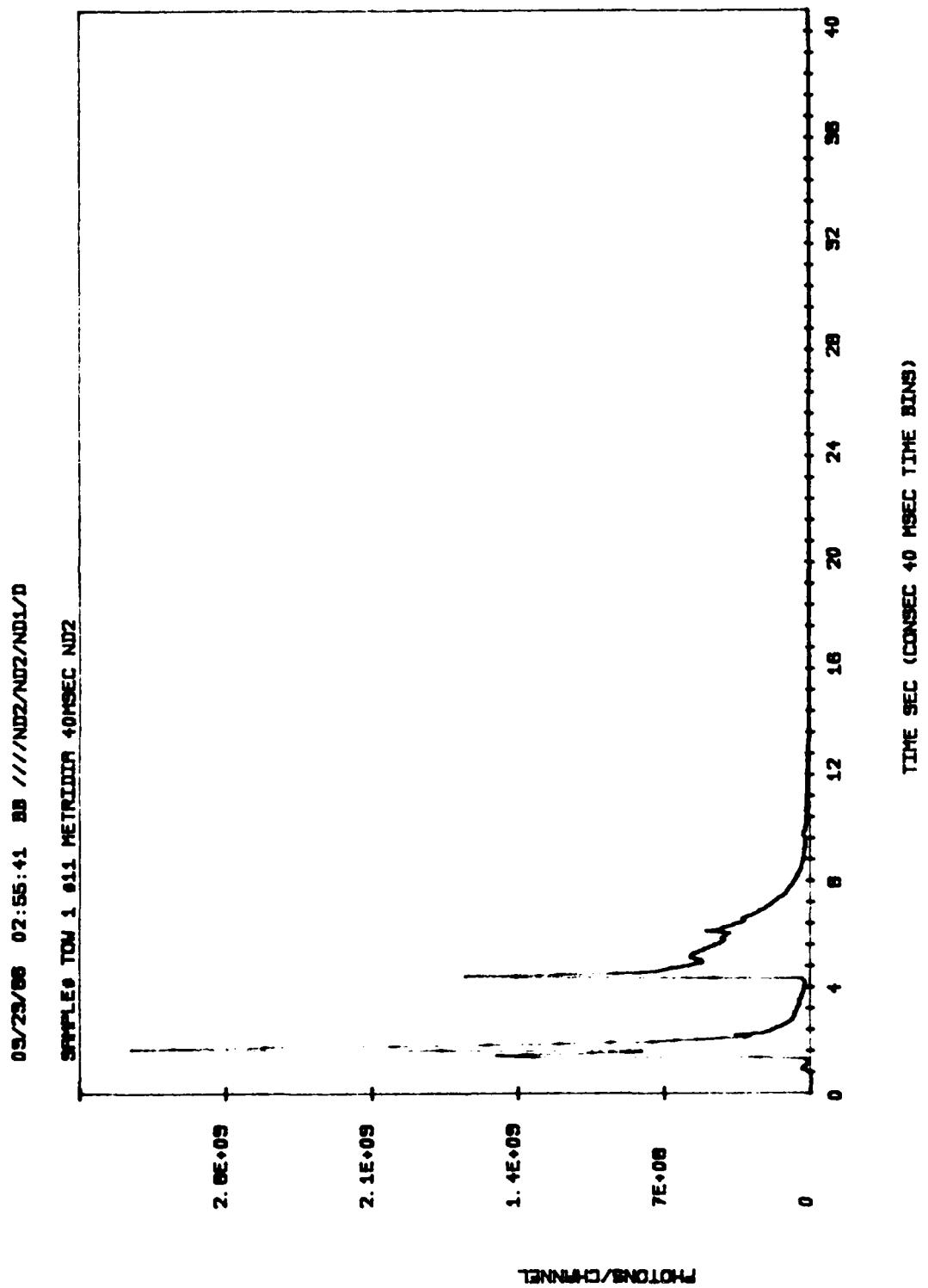
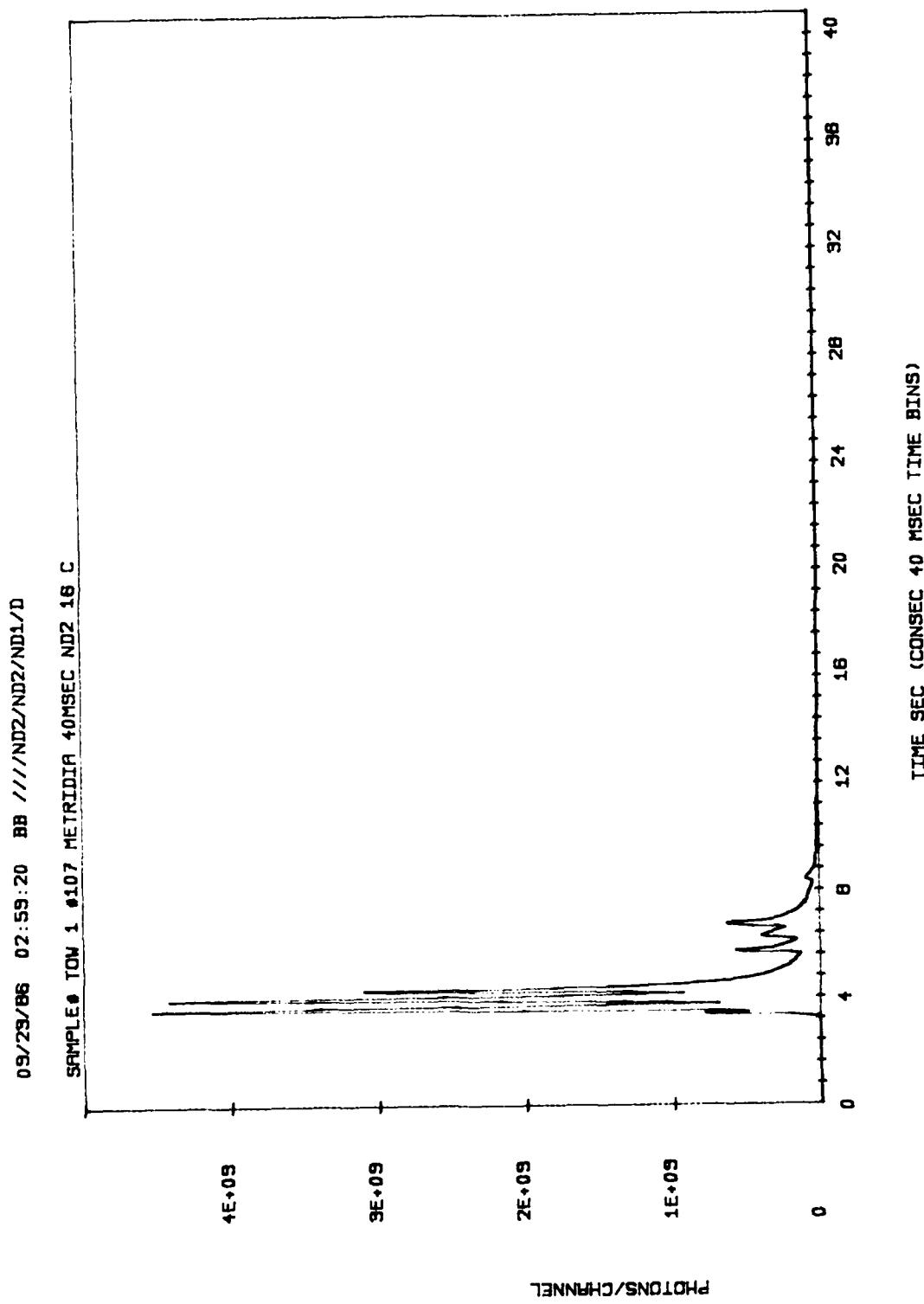


Figure C-1



C-3

Figure C-2



C-4

Figure C-3

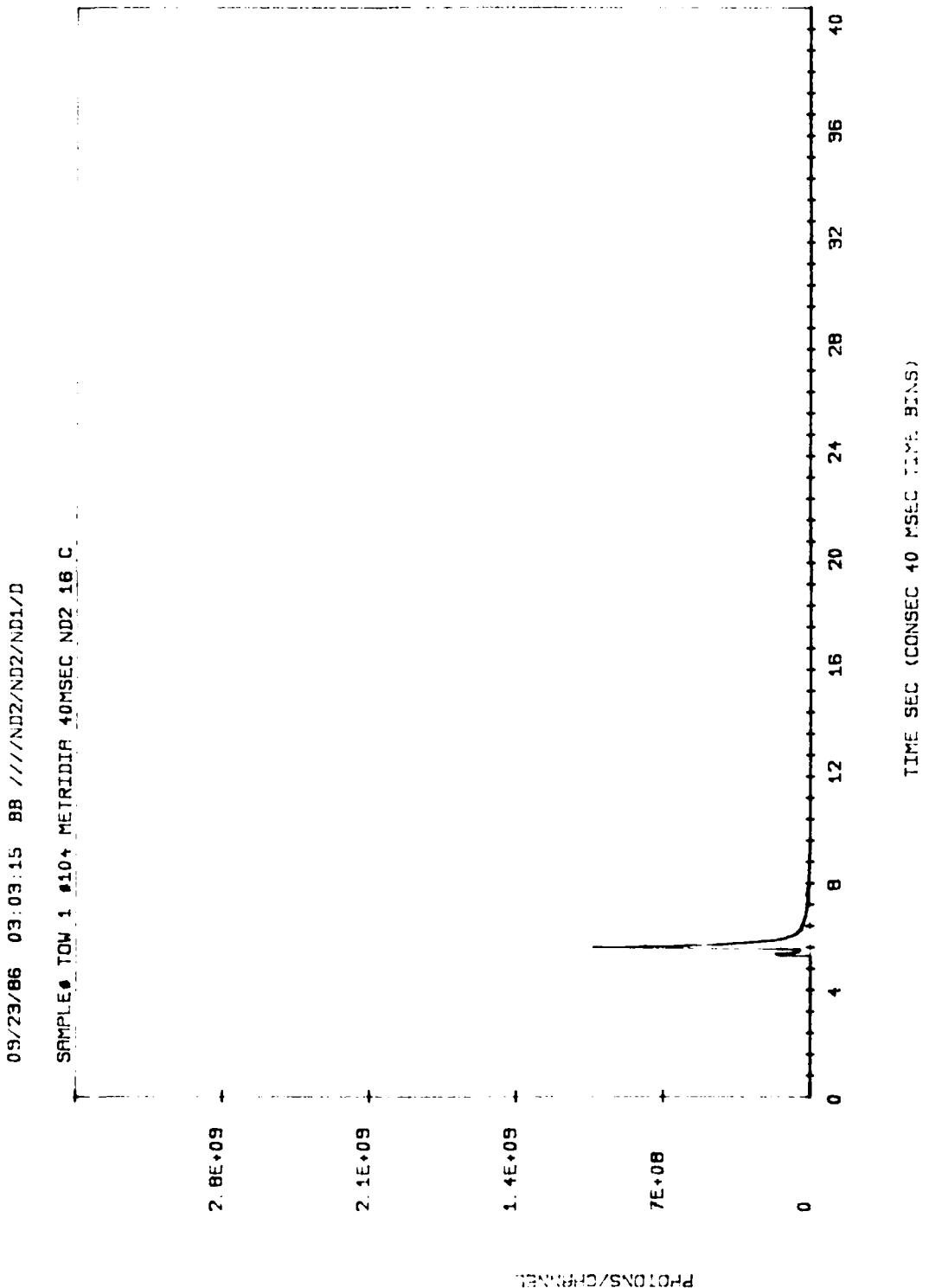
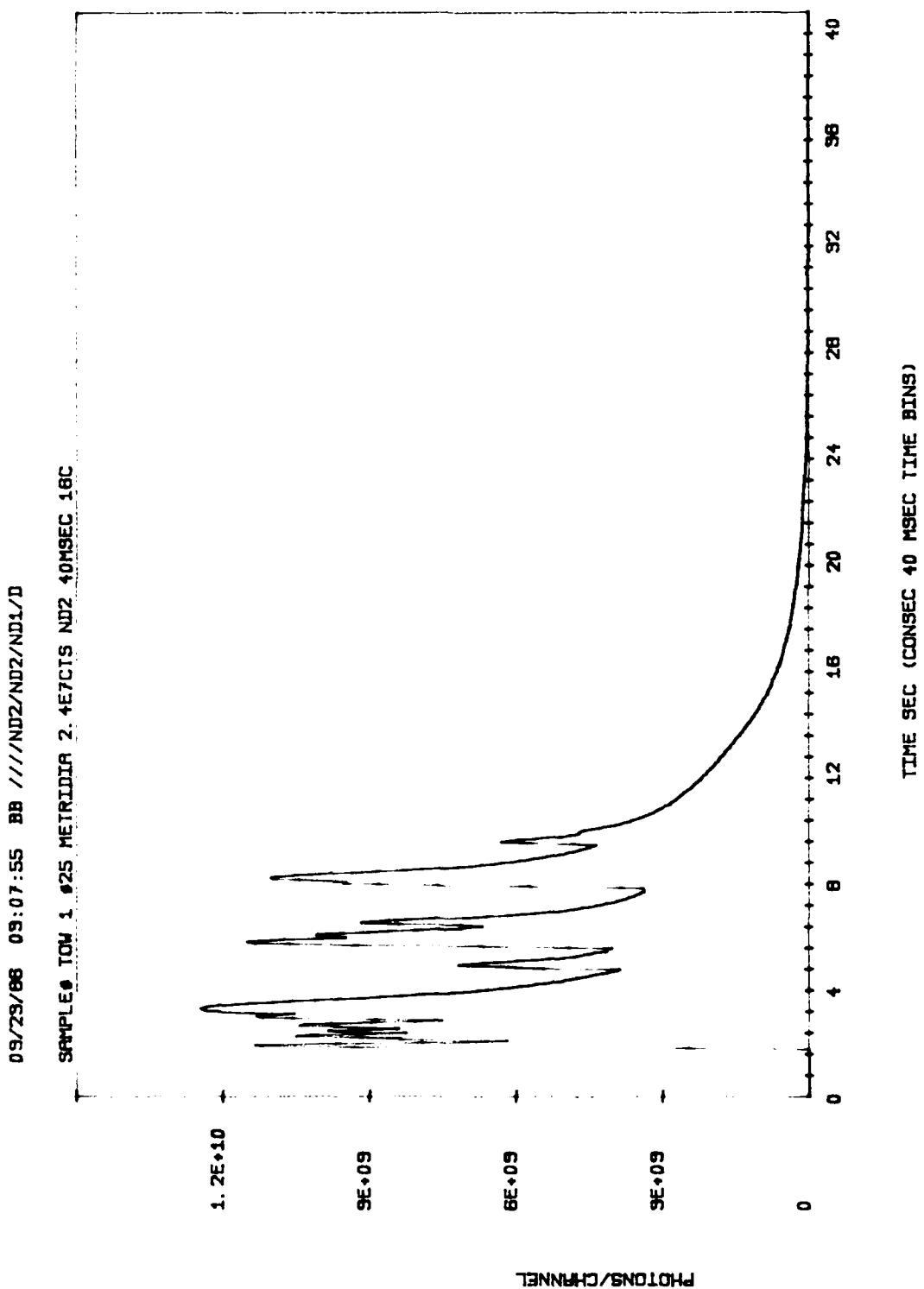


Figure C-4



C-6

Figure C-5

09/29/98 09:12:51 BB ////ND2/ND2/ND1/D

SAMPLE# TON 1 0155 METRIDA 2. 85E7CTS ND2 40MSEC 16 C

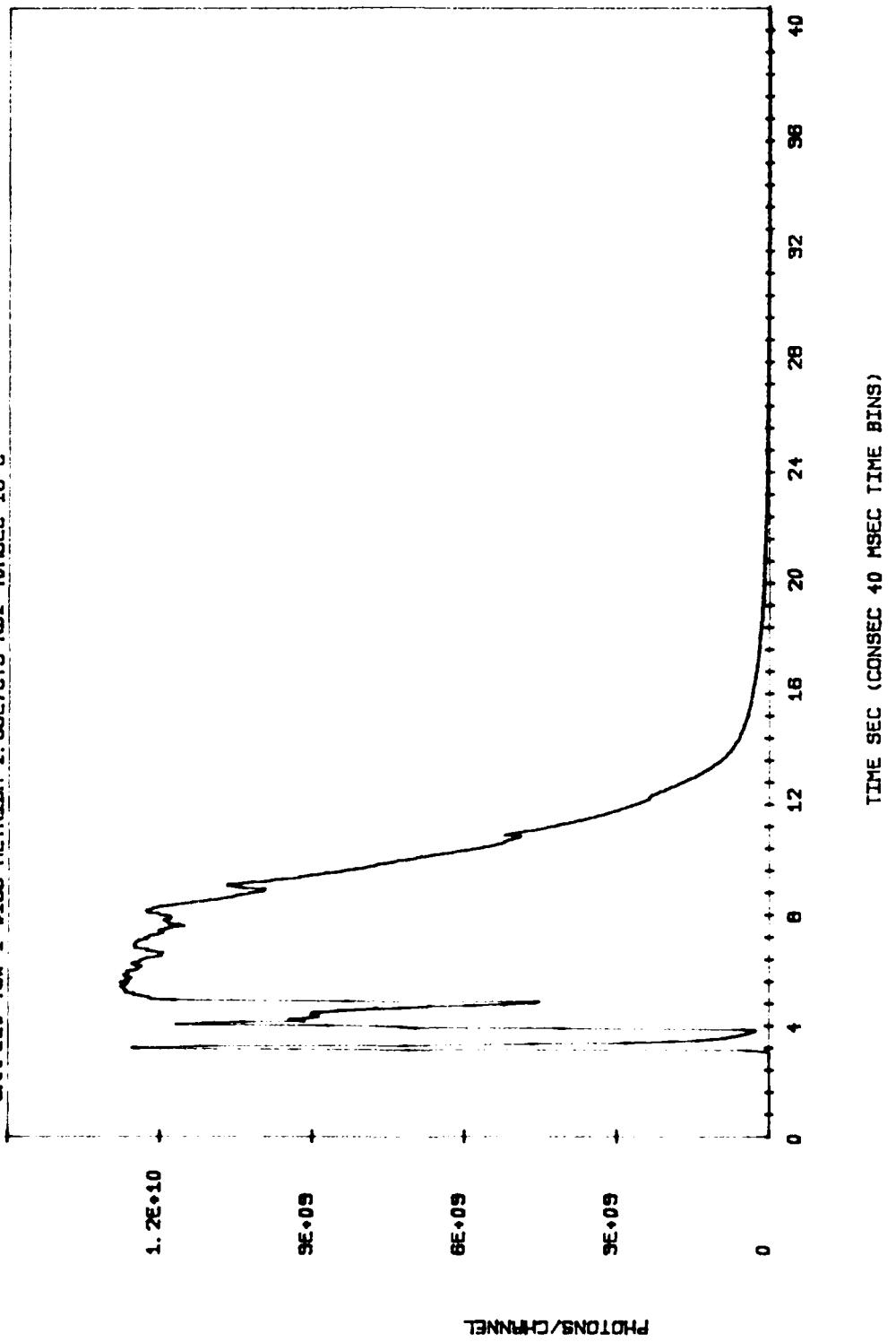
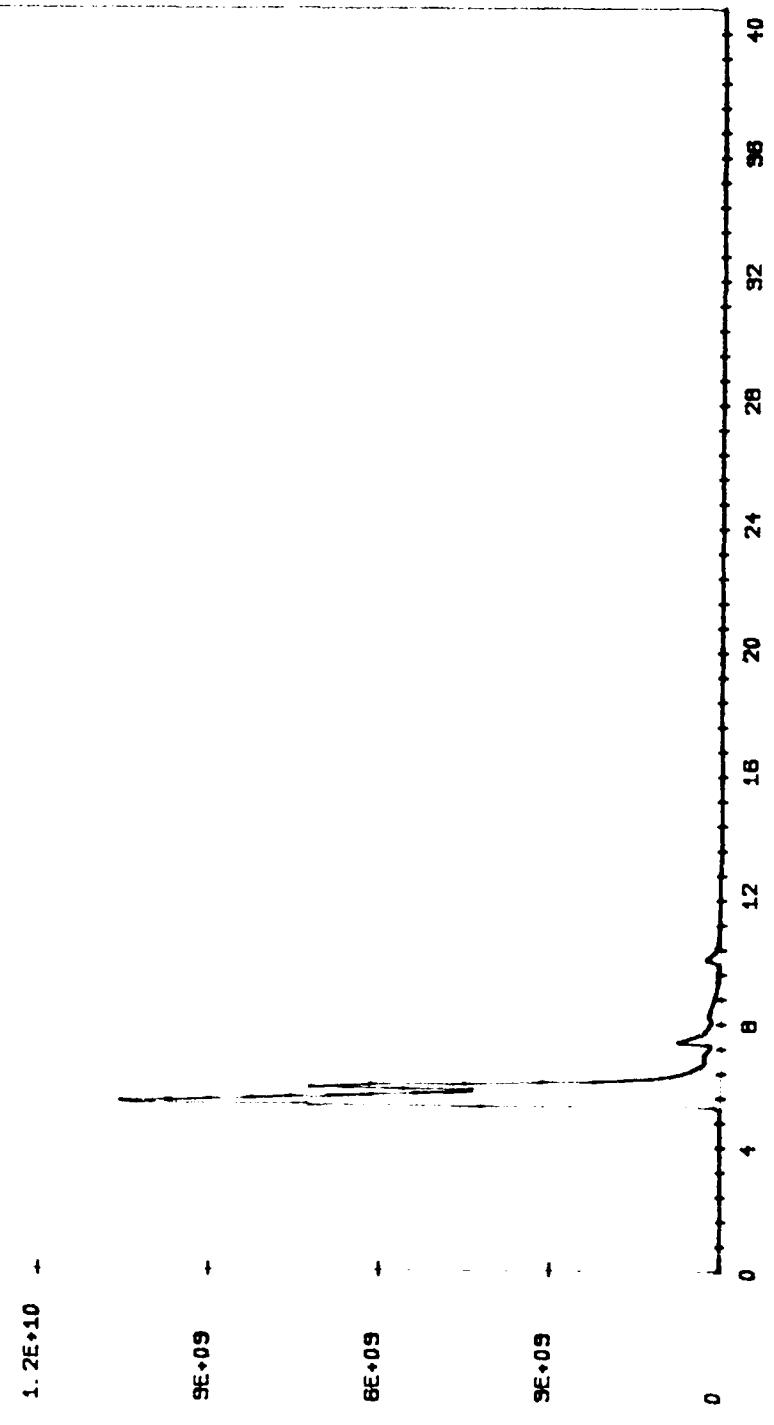


Figure C-6

09/29/86 03:18:21 BB ////ND2/ND2/ND1/D

SAMPLE# TOW 1 #153 METRIDIA 2. 28E6 CTS ND2 40MSEC 16 C

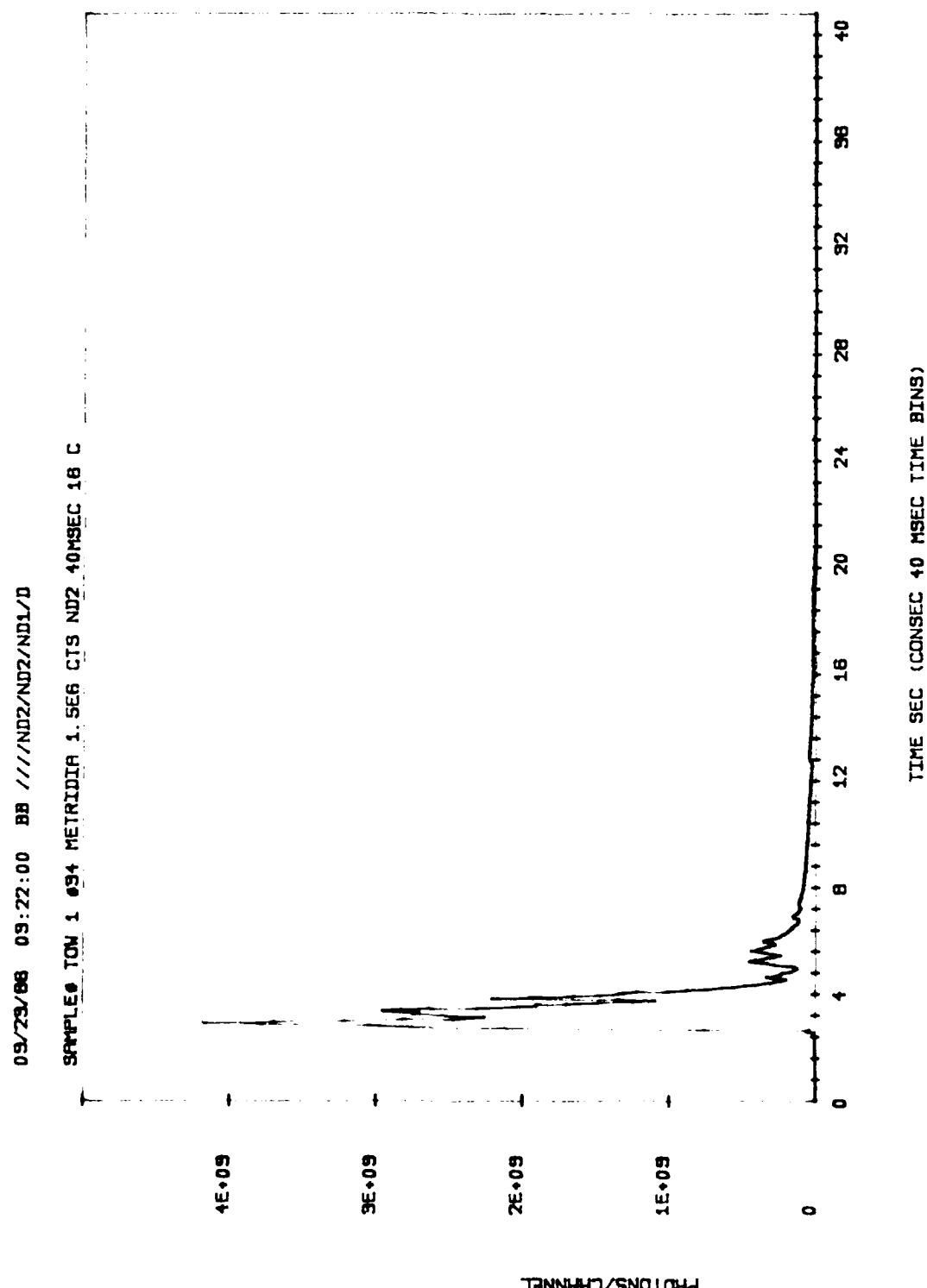


PHOTONS/CHANNEL

C-8

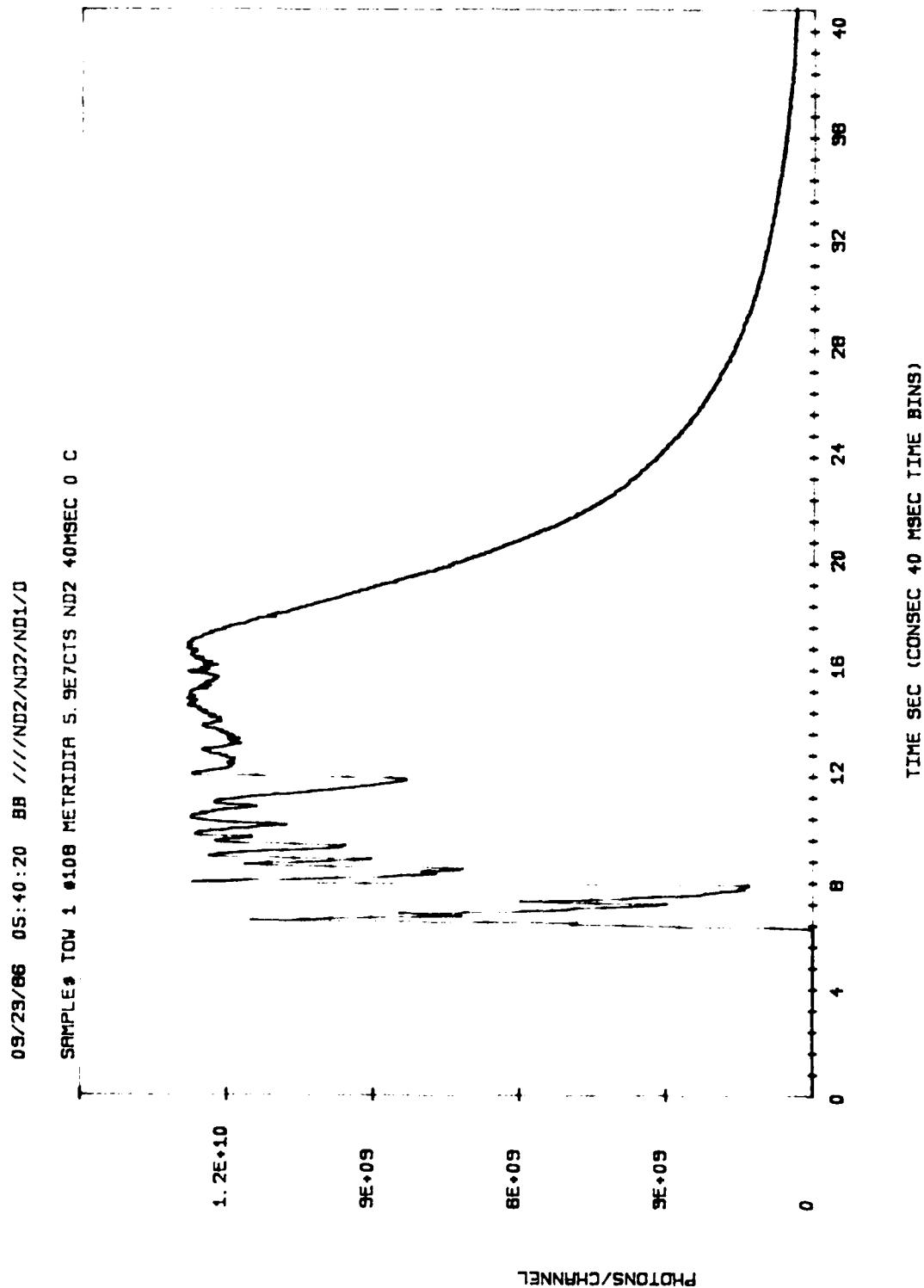
TIME SEC (CONSEC 40 MSEC TIME BINS)

Figure C-7



C-9

Figure C-8

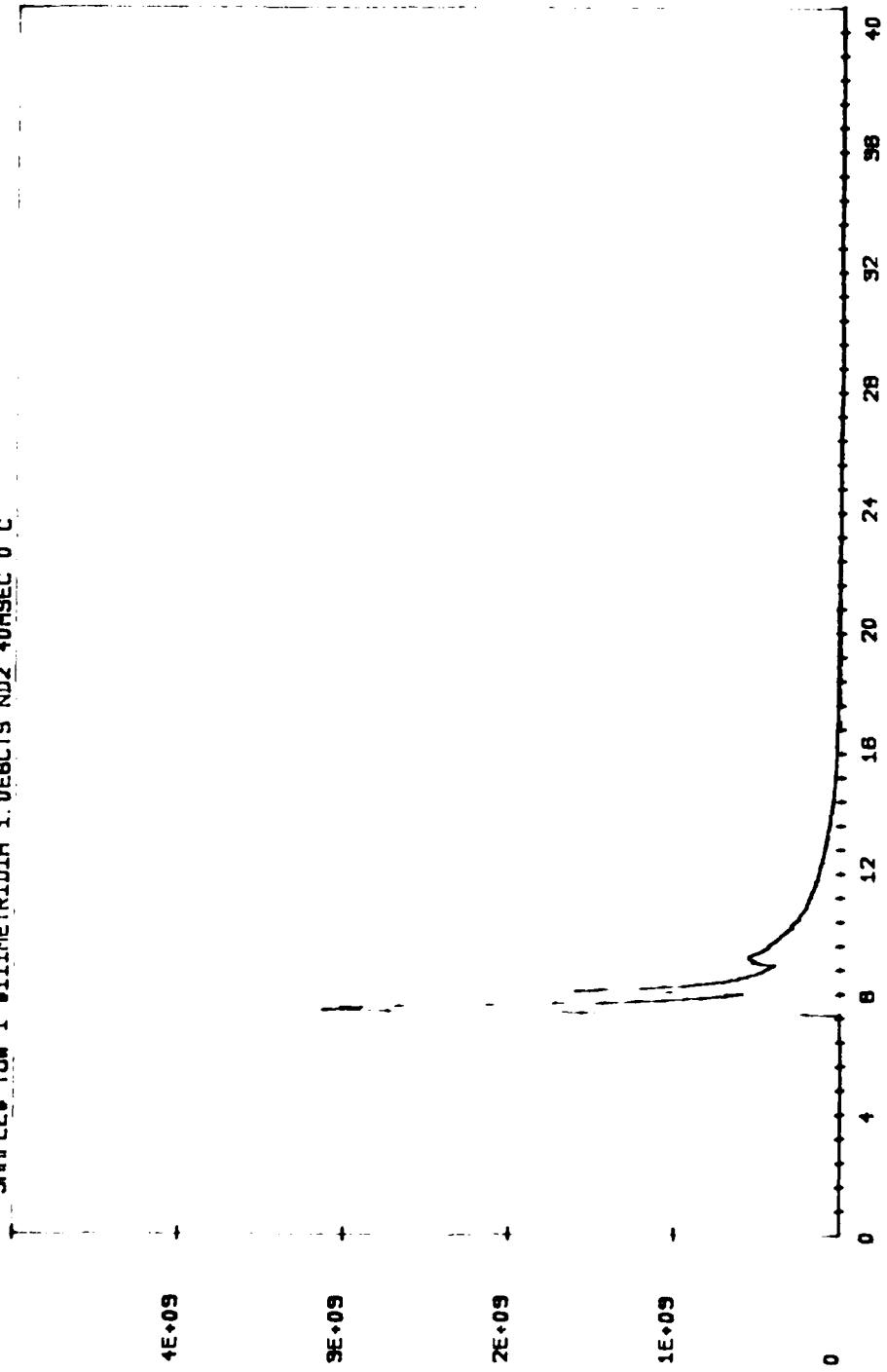


C-10

Figure C-9

09/29/88 06:24:08 BB ////ND2/ND2/ND1/D

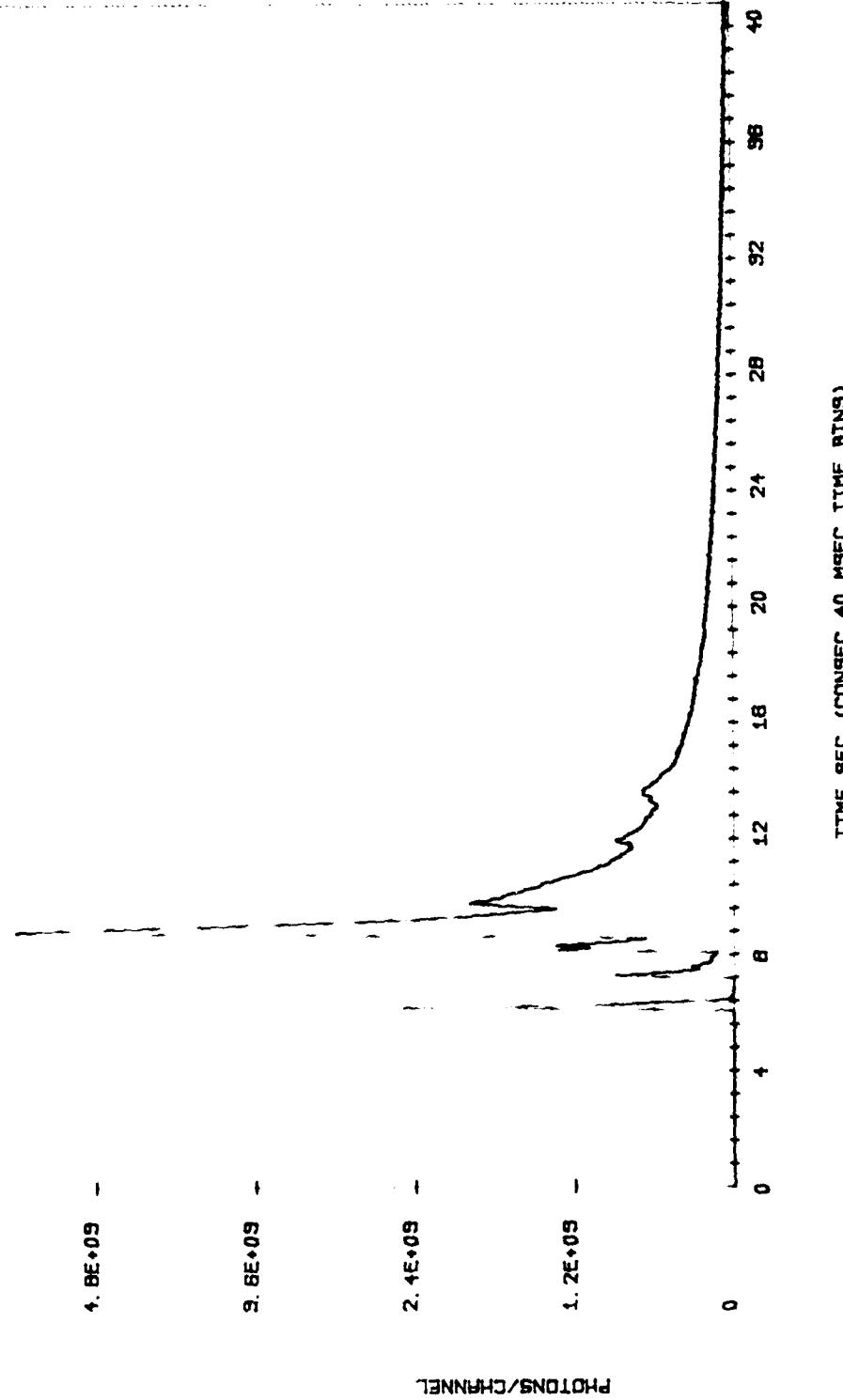
SAMPLE TOW 1 0111METR01A 1.0E8CTS ND2 40MSEC 0 C



C-11

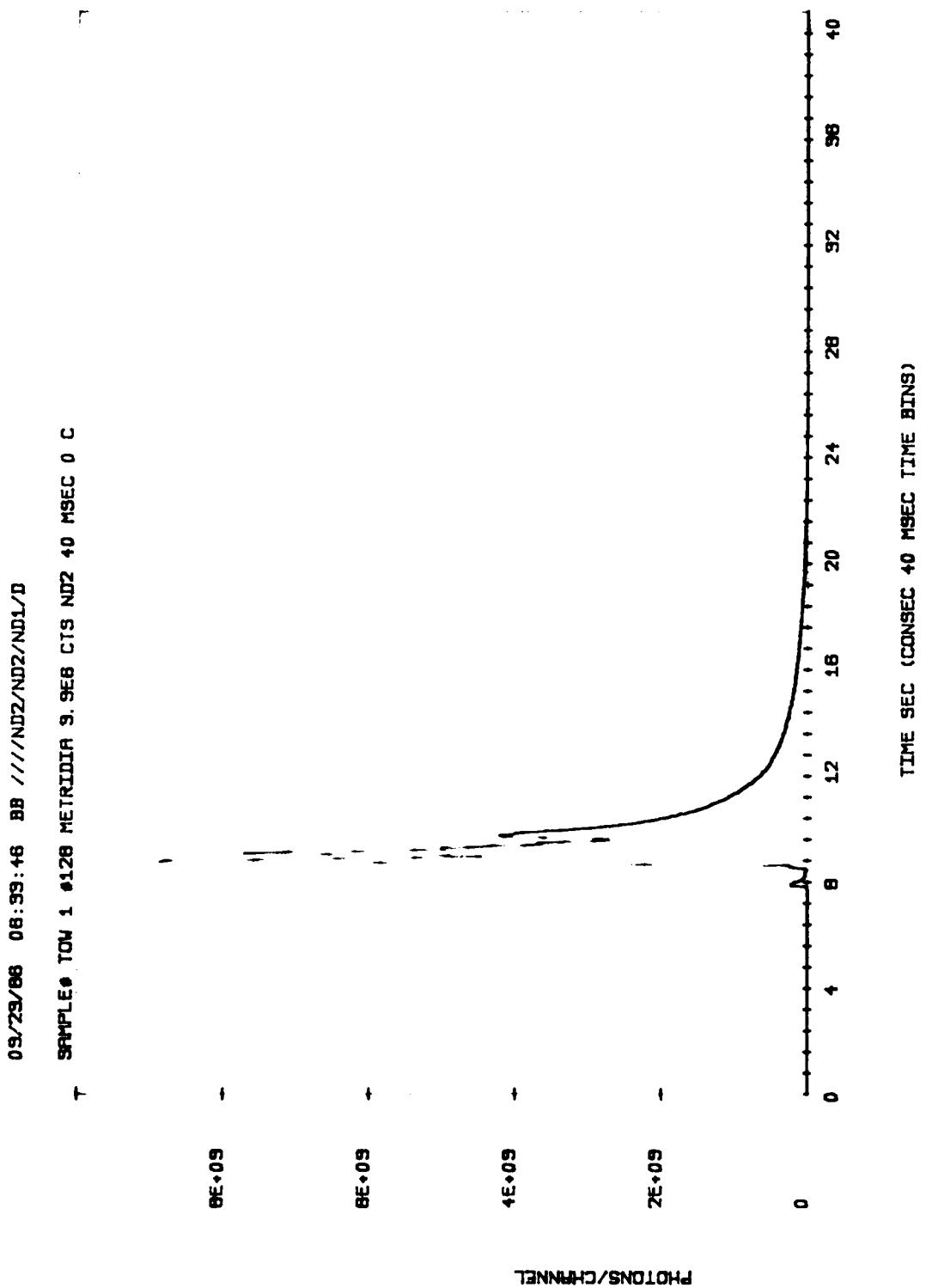
Figure C-10

09/23/86 08:29:02 BB ////ND2/ND2/ND1/D
SAMPLE# TCH 1 #114 METRDIR 4E8CTS ND2 40MSEC 0 C



C-12

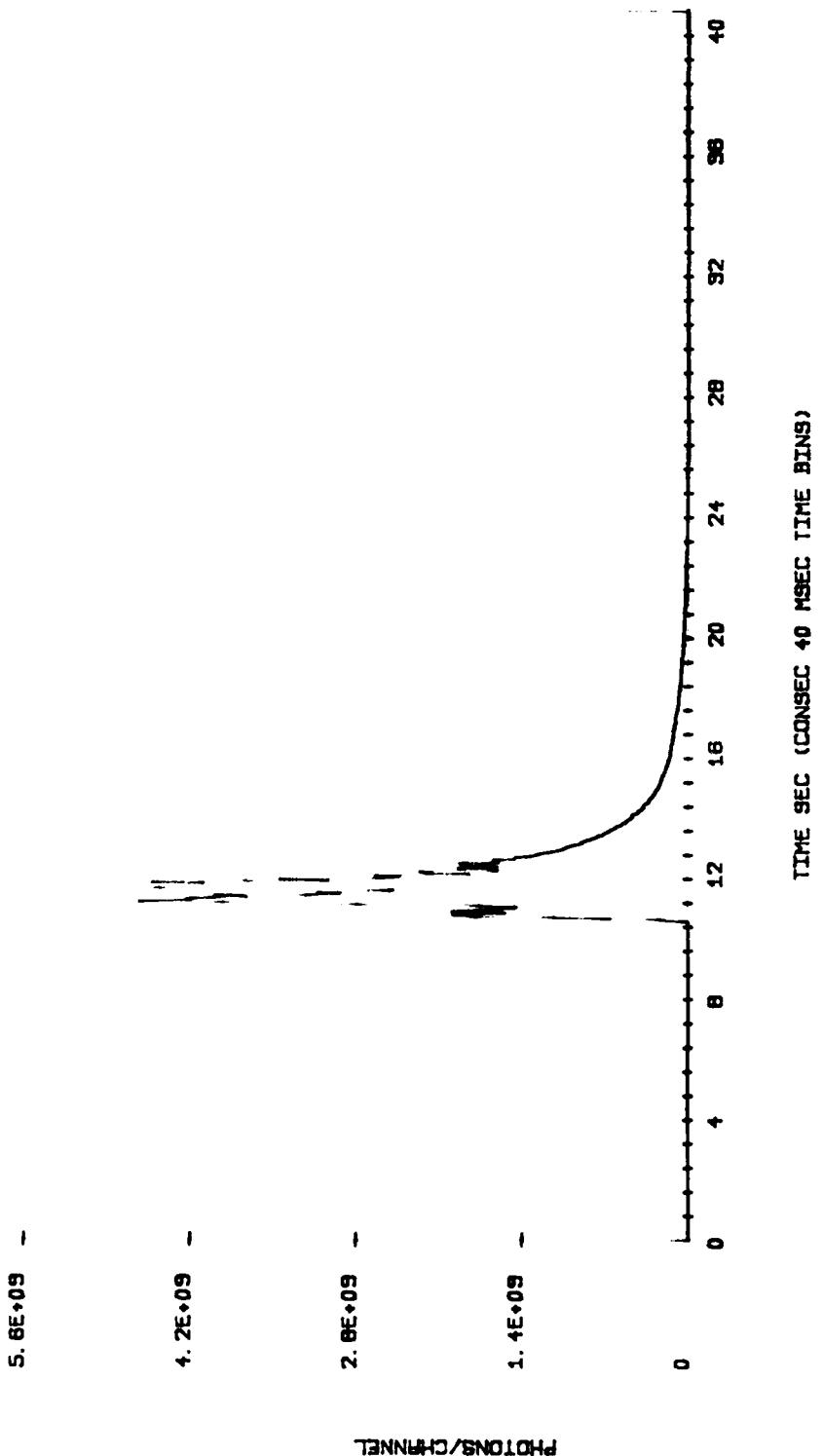
Figure C-11



C-13

Figure C-12

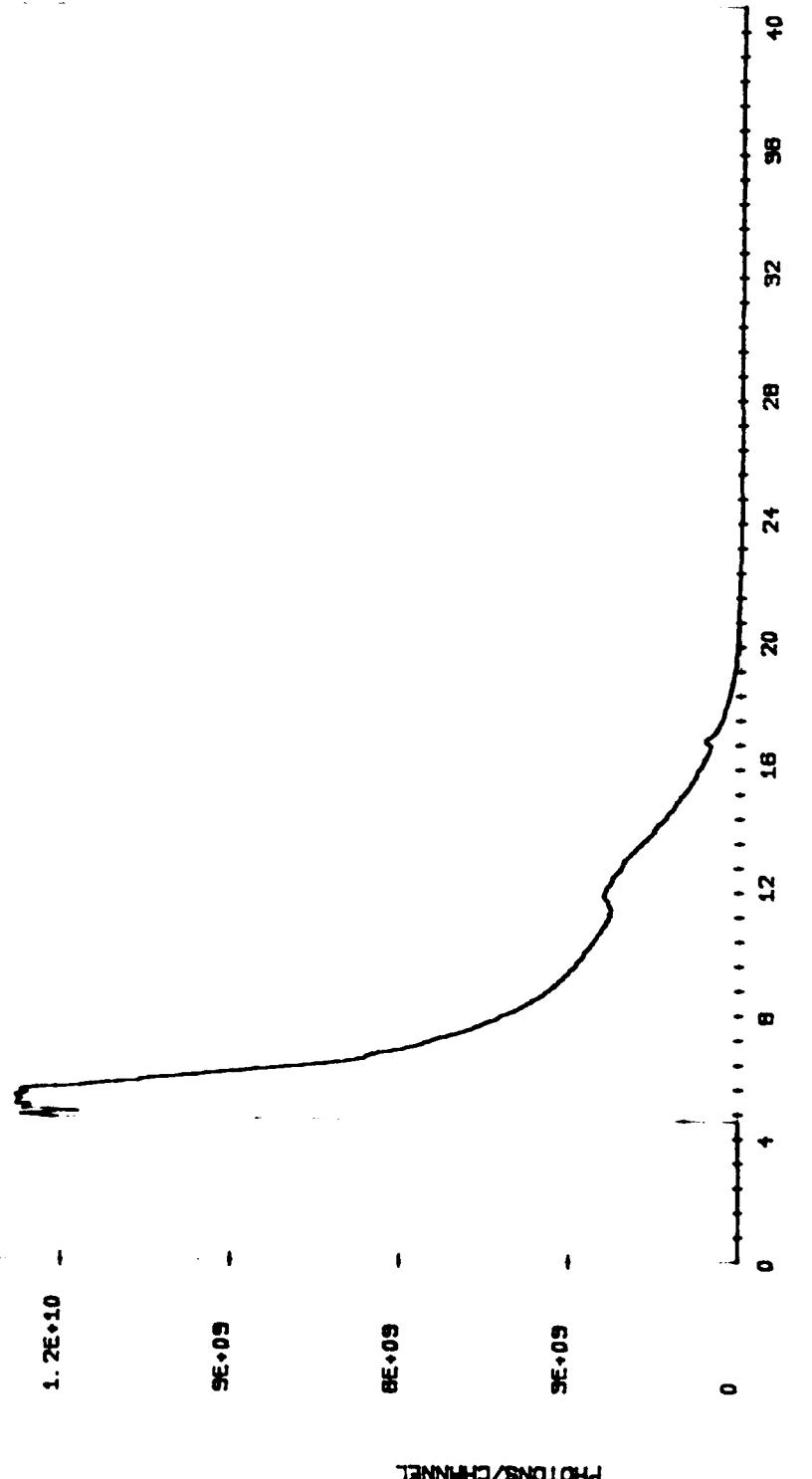
09/23/68 06:39:03 BB ////ND2/ND2/ND1/D
SAMPLE TOW 1 #166 METRIDIA 2.7E8 CTS ND2 40 MSEC 0 C



C-14

Figure C-13

09/23/88 06:44:20 BB ////ND2/ND2/ND1/0
SAMPLE# TOW# 1 #130 METRIDA 1.7E7 CTS ND2 40 MSEC 0 C



C-15

Figure C-14

09/23/86 06:49:48 BB ////ND2/ND2/ND1/0
SAMPLE# TOW# 1 #110 METRIDIUM 5.2E5 CTS ND2 40 MSEC 0.0

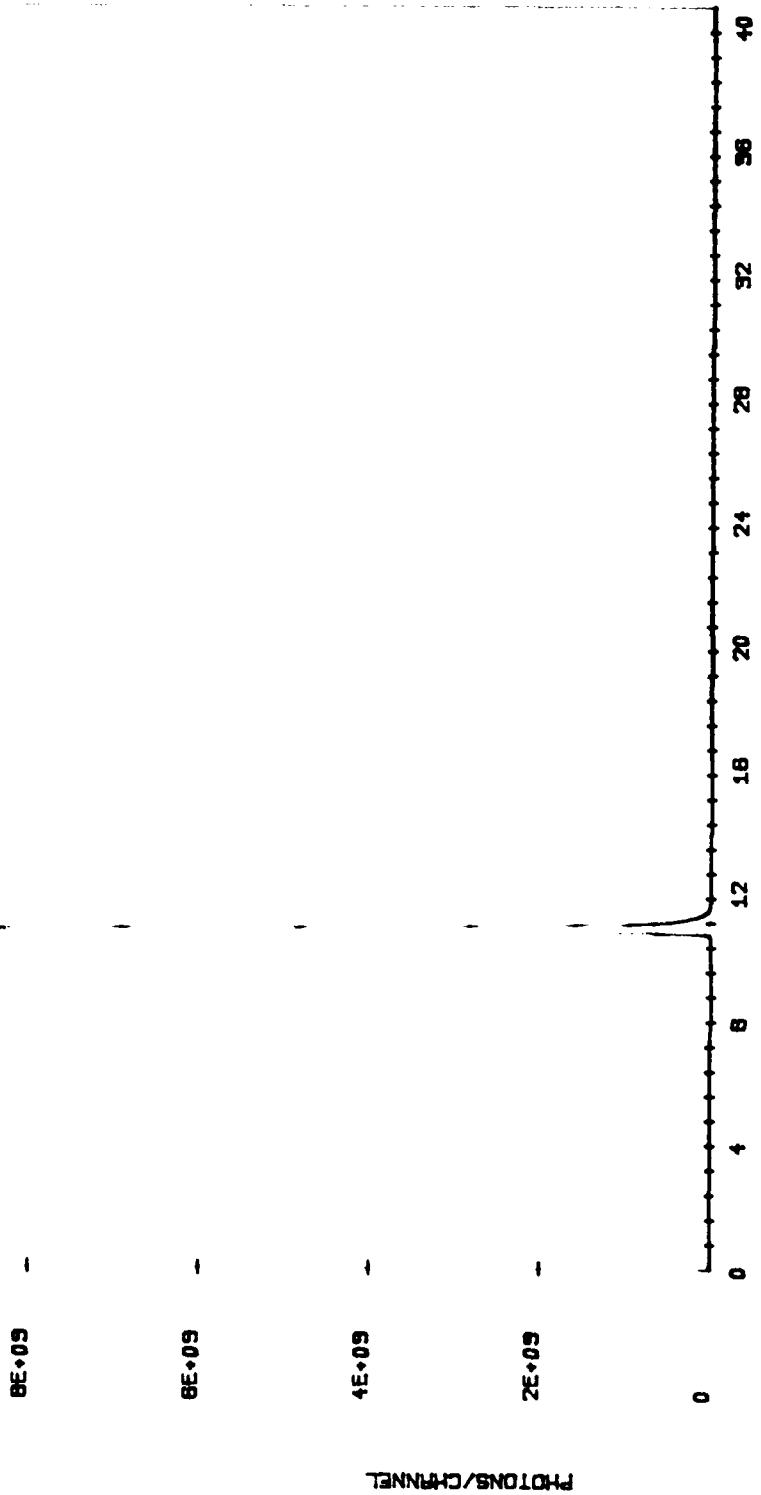
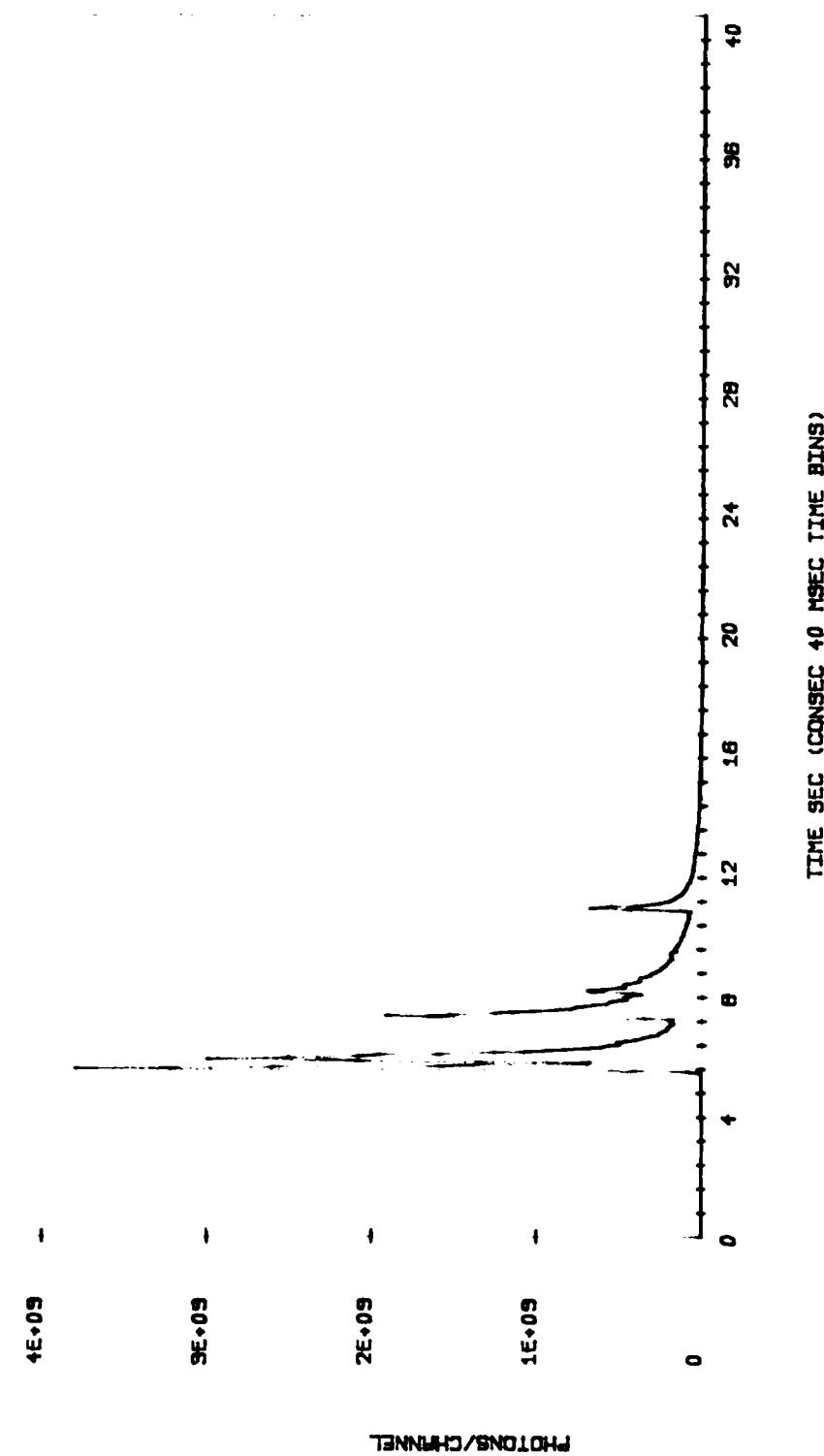


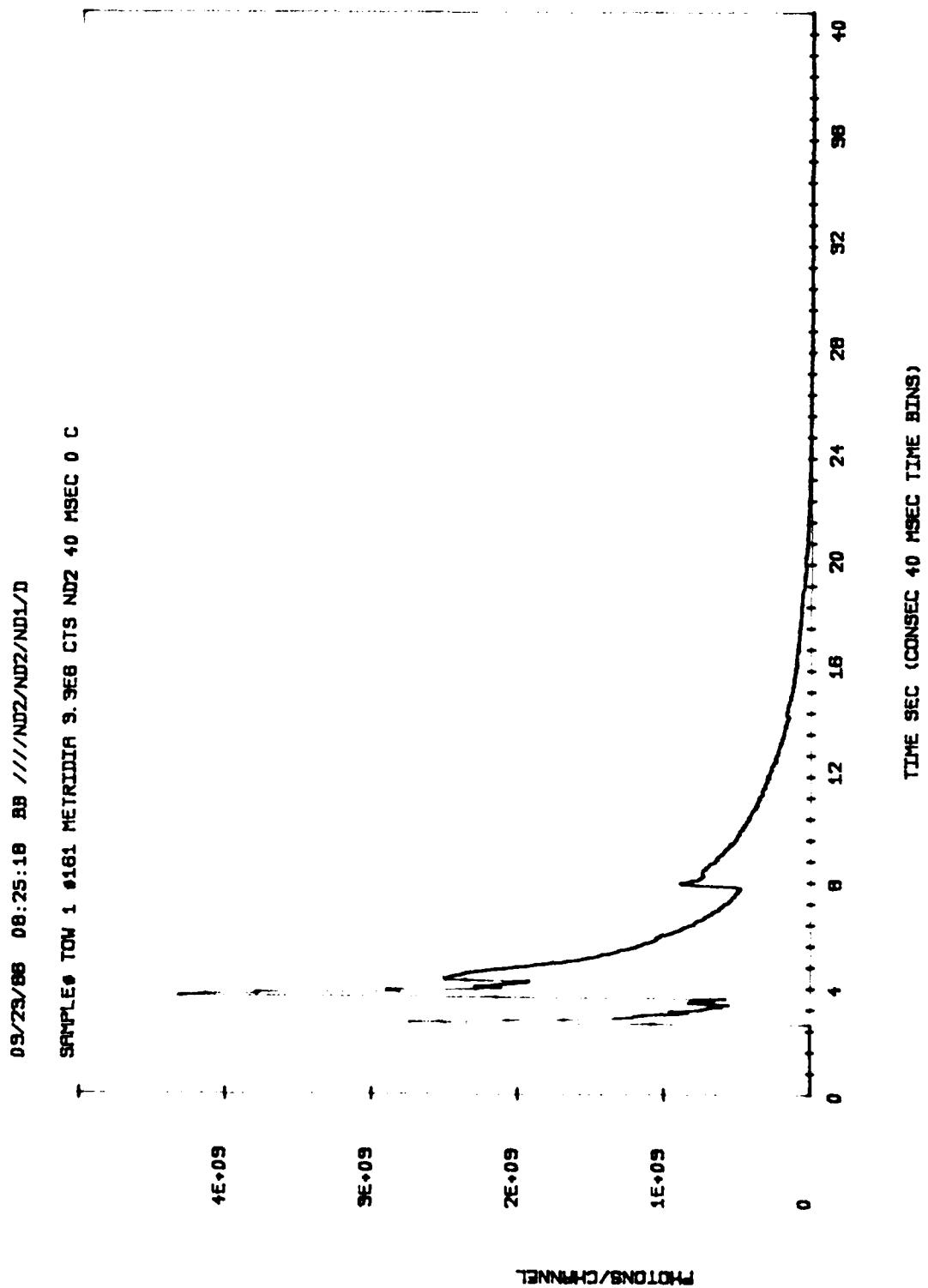
Figure C-15

09/23/68 08:20:37 BB ////ND2/ND2/ND1/D
SAMPLE TOW 1 #141 METRICIA 1.1E8 CTS ND2 40 MSEC 0 C



C-17

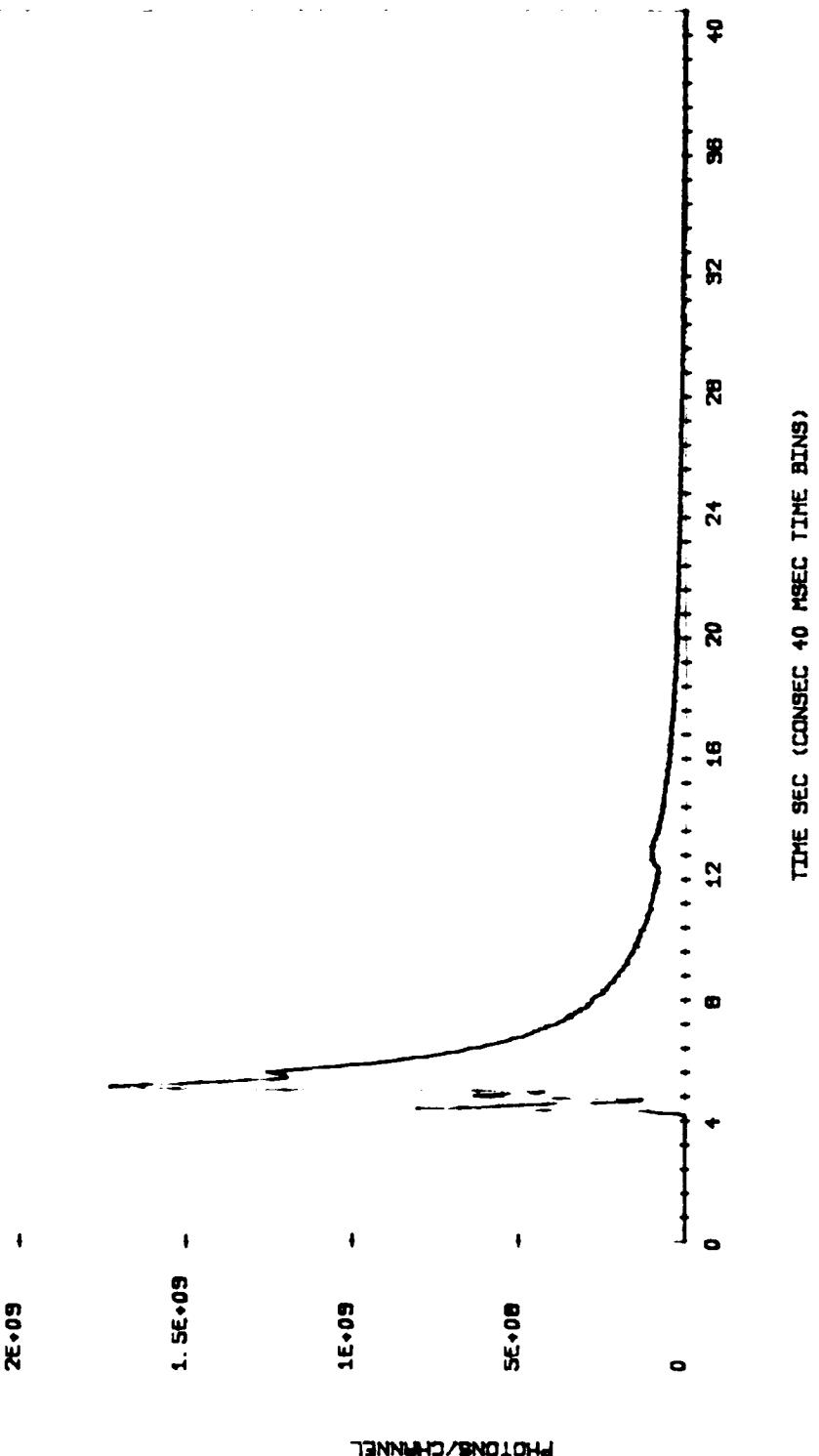
Figure C-16



C-18

Figure C-17

09/23/88 08:39:03 BB ////ND2/ND2/ND1/D
+ SAMPLE# TON 1 0149 METRODIA ? (SMALL) 1.2E8 CTS ND2 40MSEC 0 C



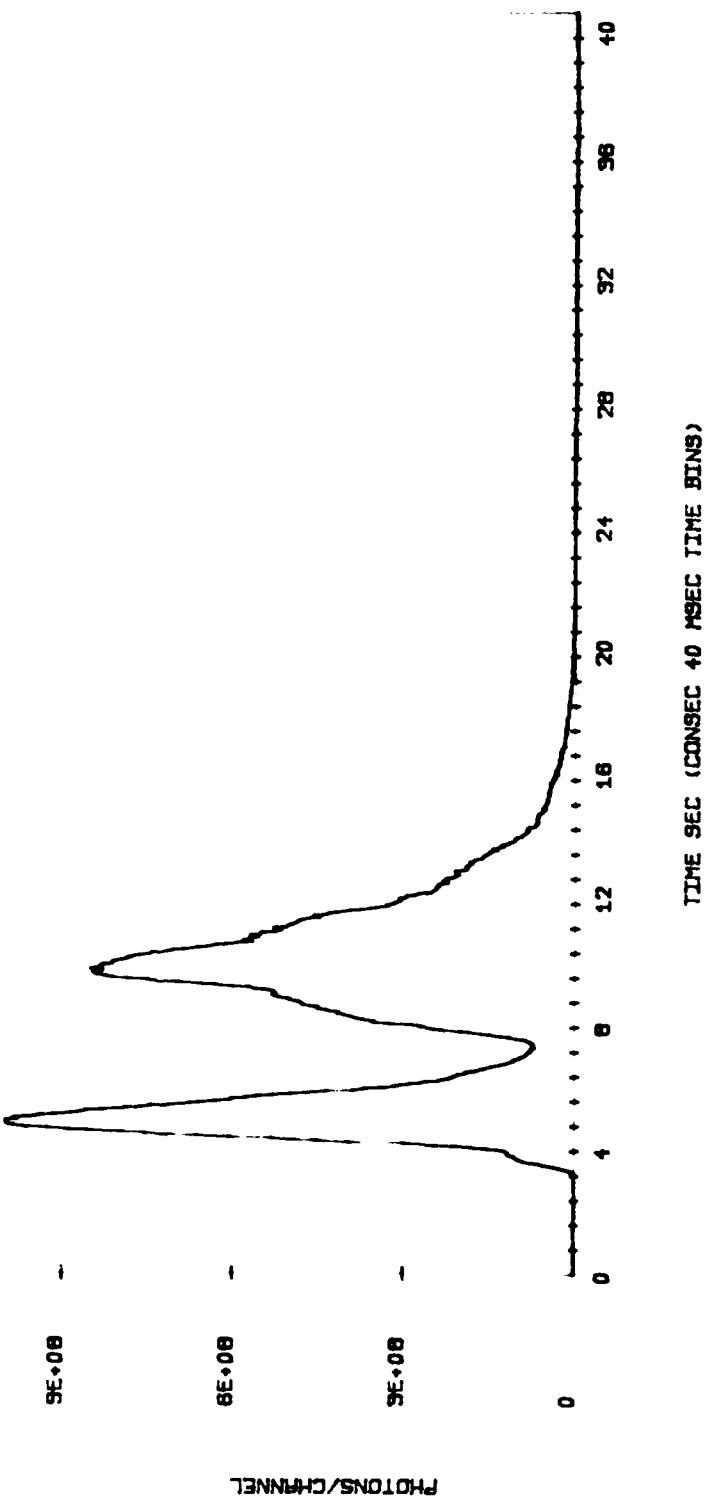
C-19

Figure C-18

09/23/88 08:54:52 BB ////ND2/ND2/ND1/D

SAMPLE# TOW 1 #17

1.2E+09 -



C-20

Figure C-19

09/24/98 09:31:42 BB ////ND2/ND2/ND1/D
SAMPLE TOW 9 #107 LARVACEAN 9.1E4 CTS ND2 40MSEC

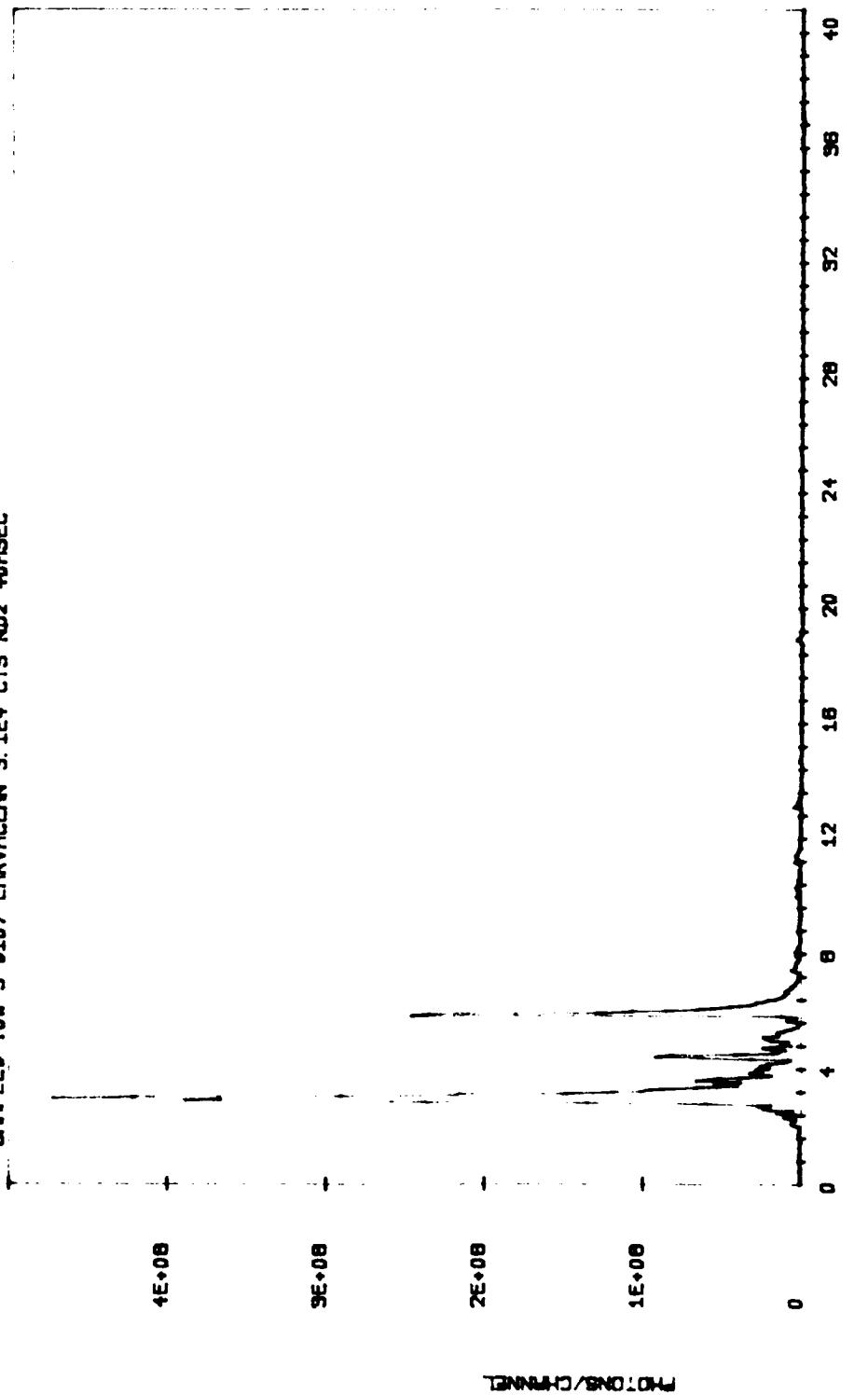


Figure C-20

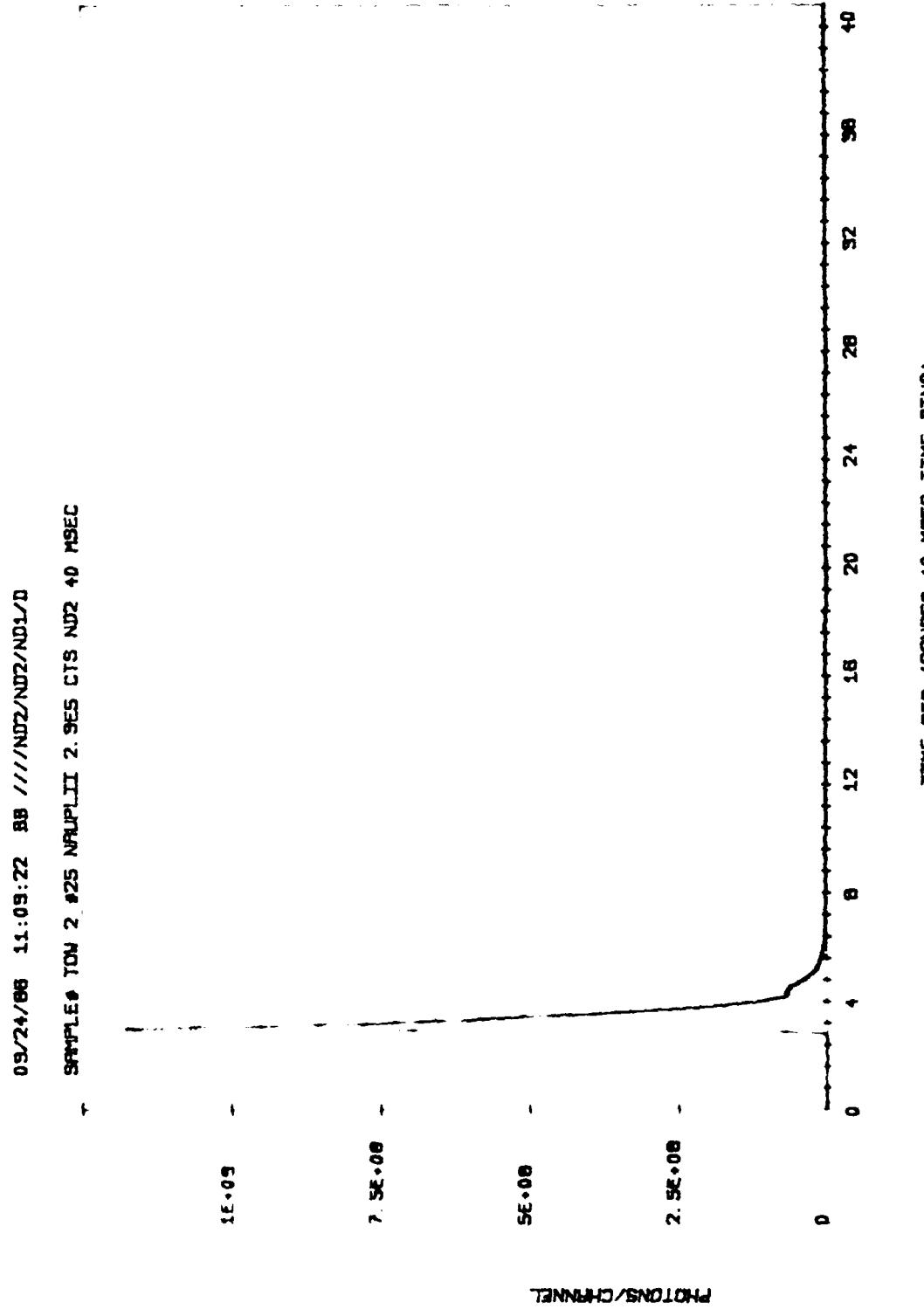
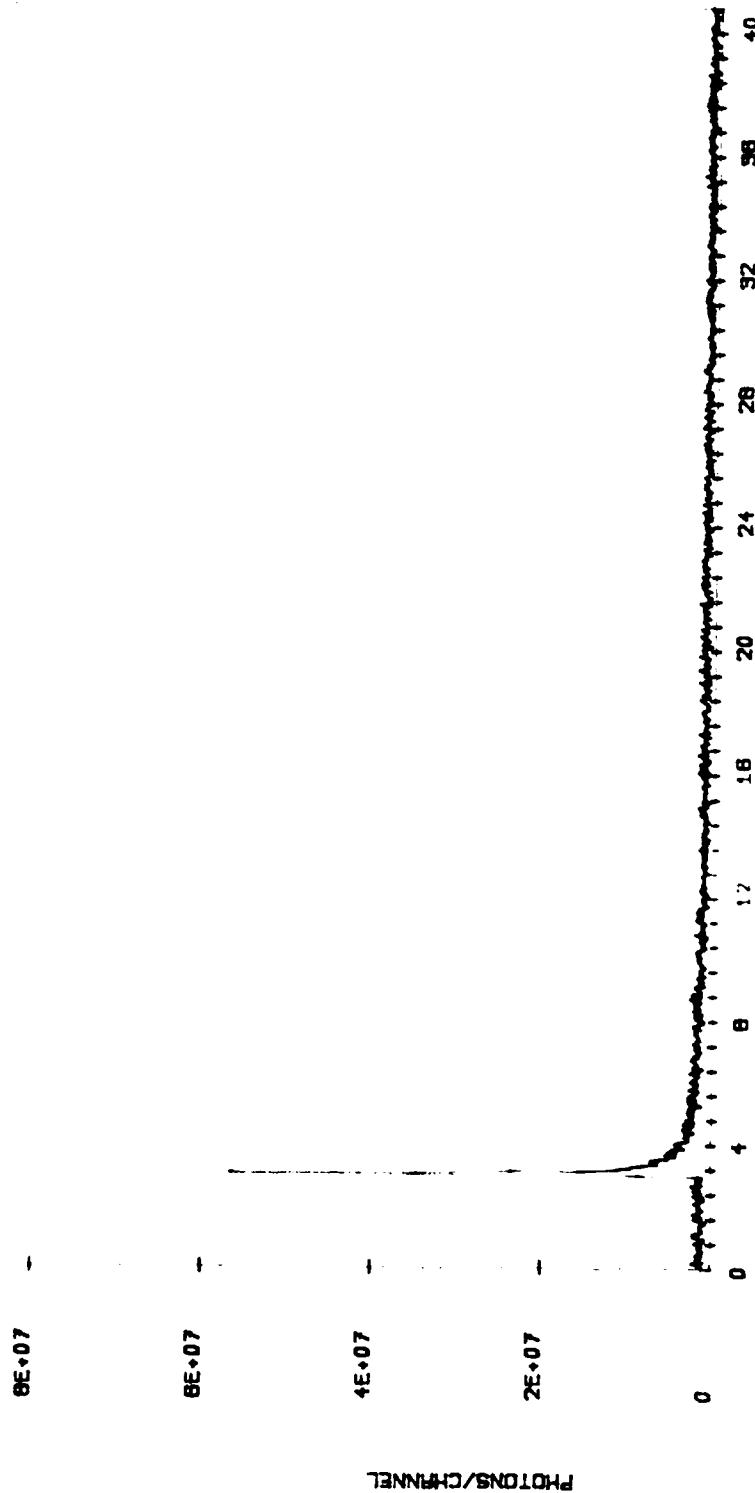


Figure C-21

09/24/00 11:13:17 BB /////ND2/ND2/ND1/D
SAMPLE TDS 2 0101 NRUPLI 4.8E3 CTS ND2 40 MSEC



C-23

Figure C-22

03/24/86 11:17:59 BB ////ND2/ND2/ND2/ND2/D
SAMPLE# TOW# 0111 NRPLTUS 0. SE4 CTS ND2 40 MSEC

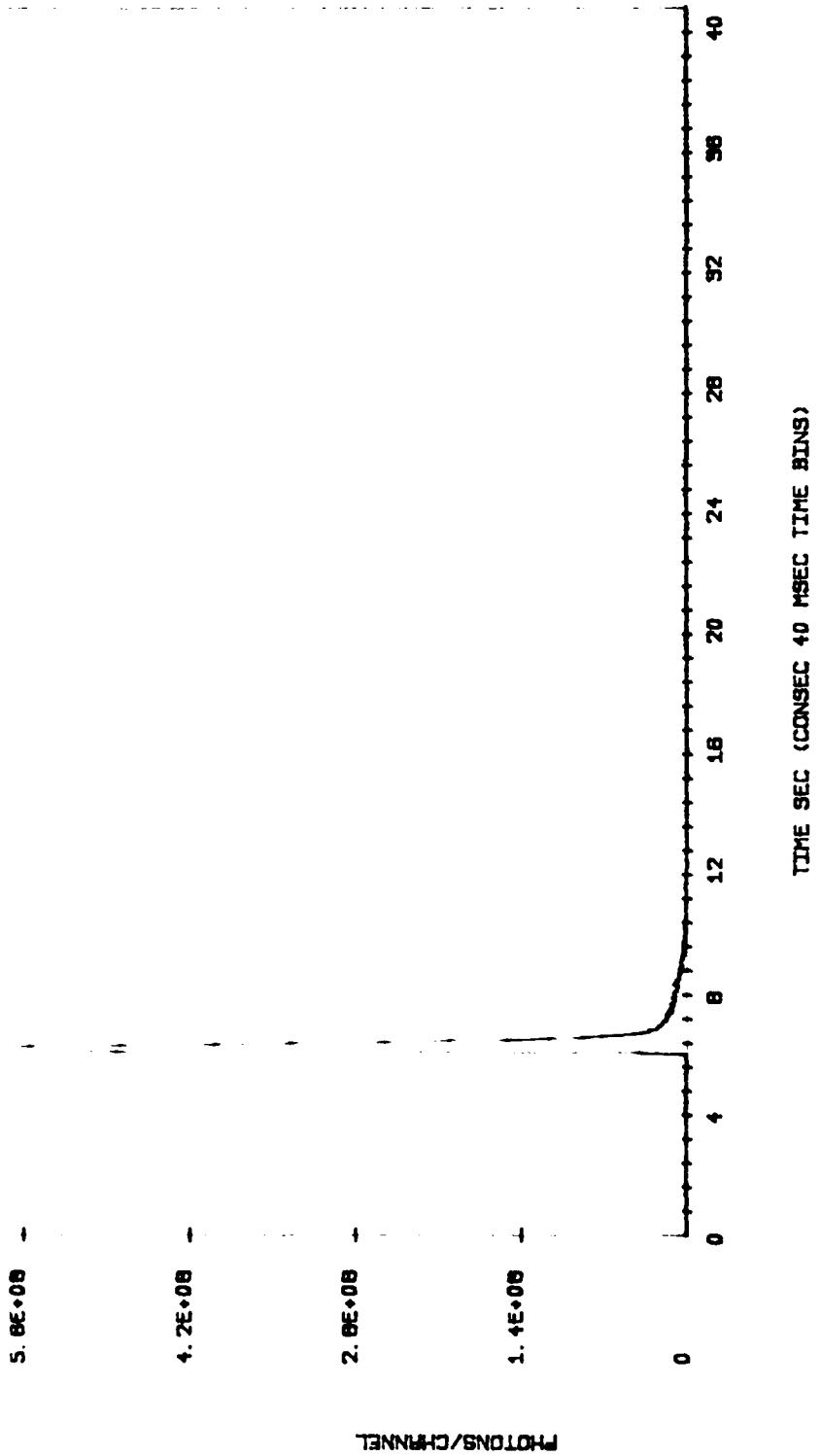
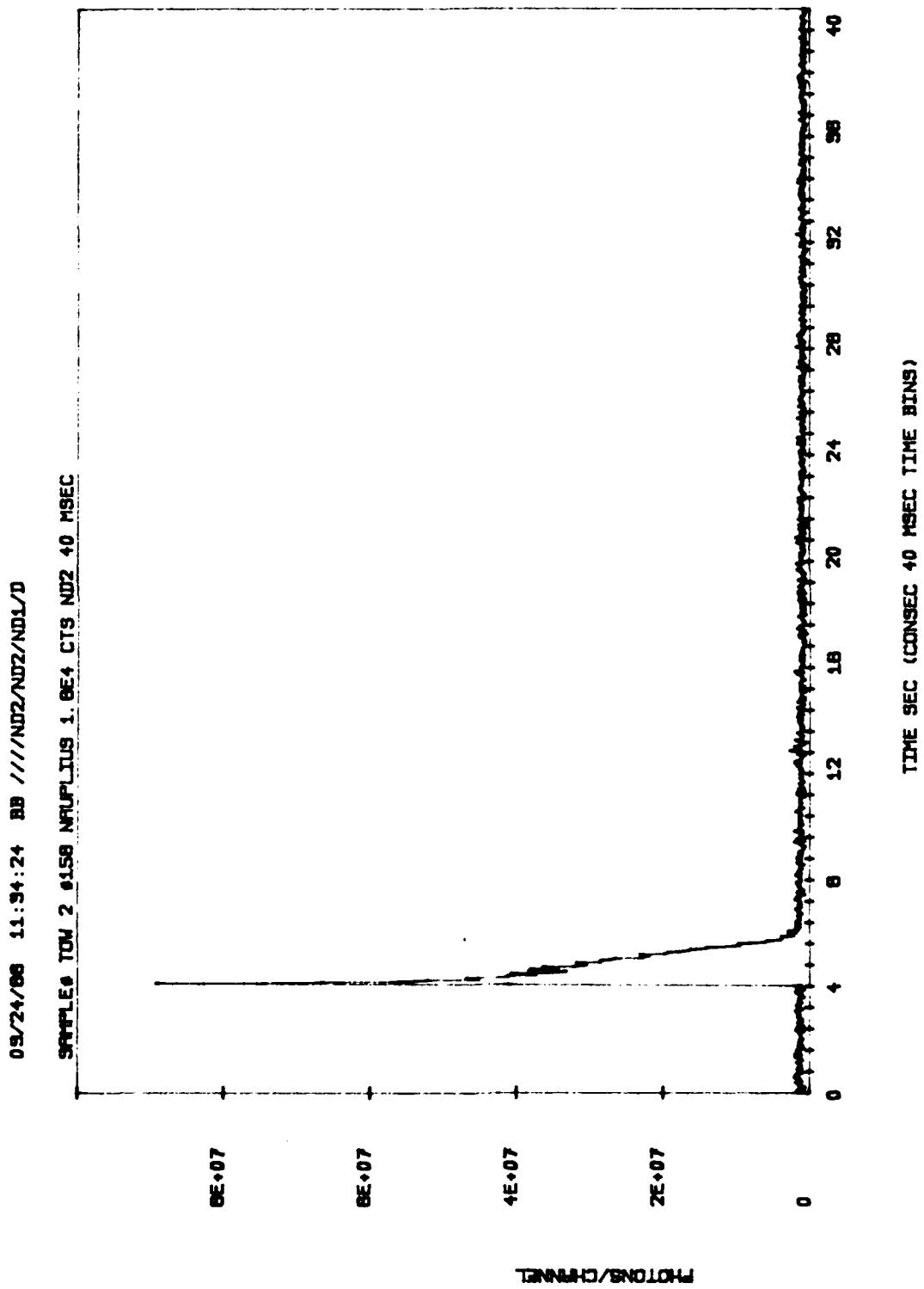
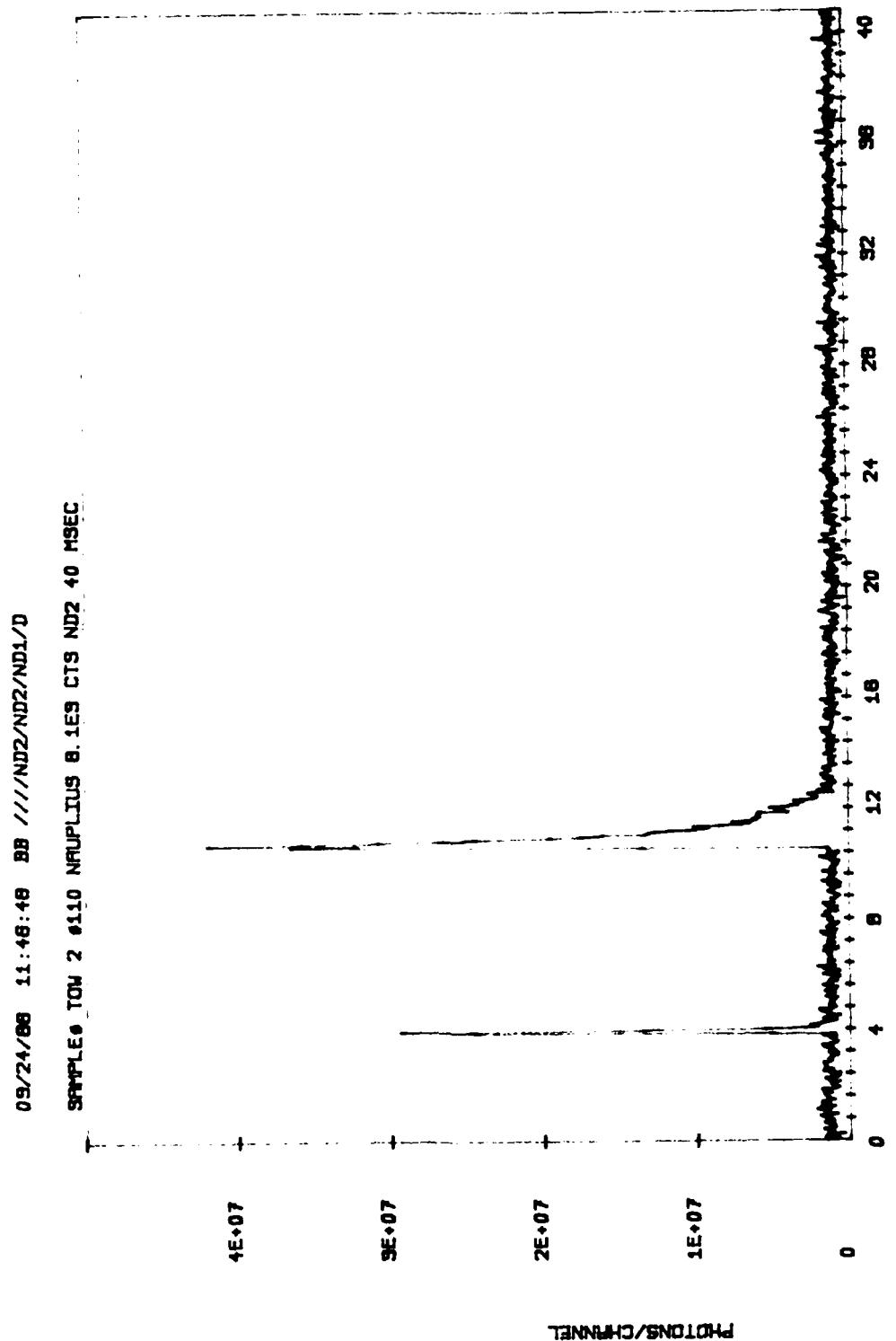


Figure C-23



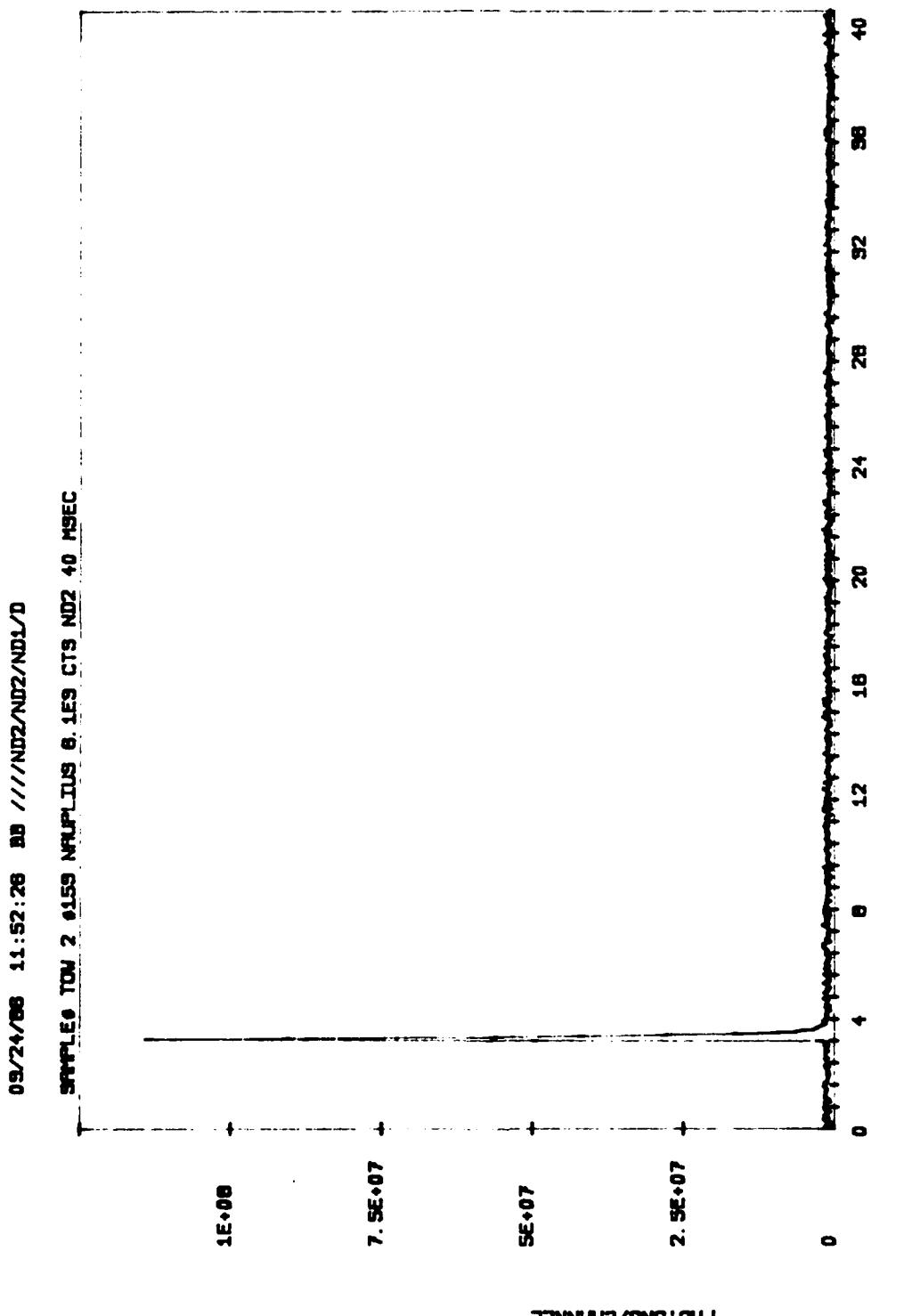
C-25

Figure C-24



C-26

Figure C-25



C-27

Figure C-26

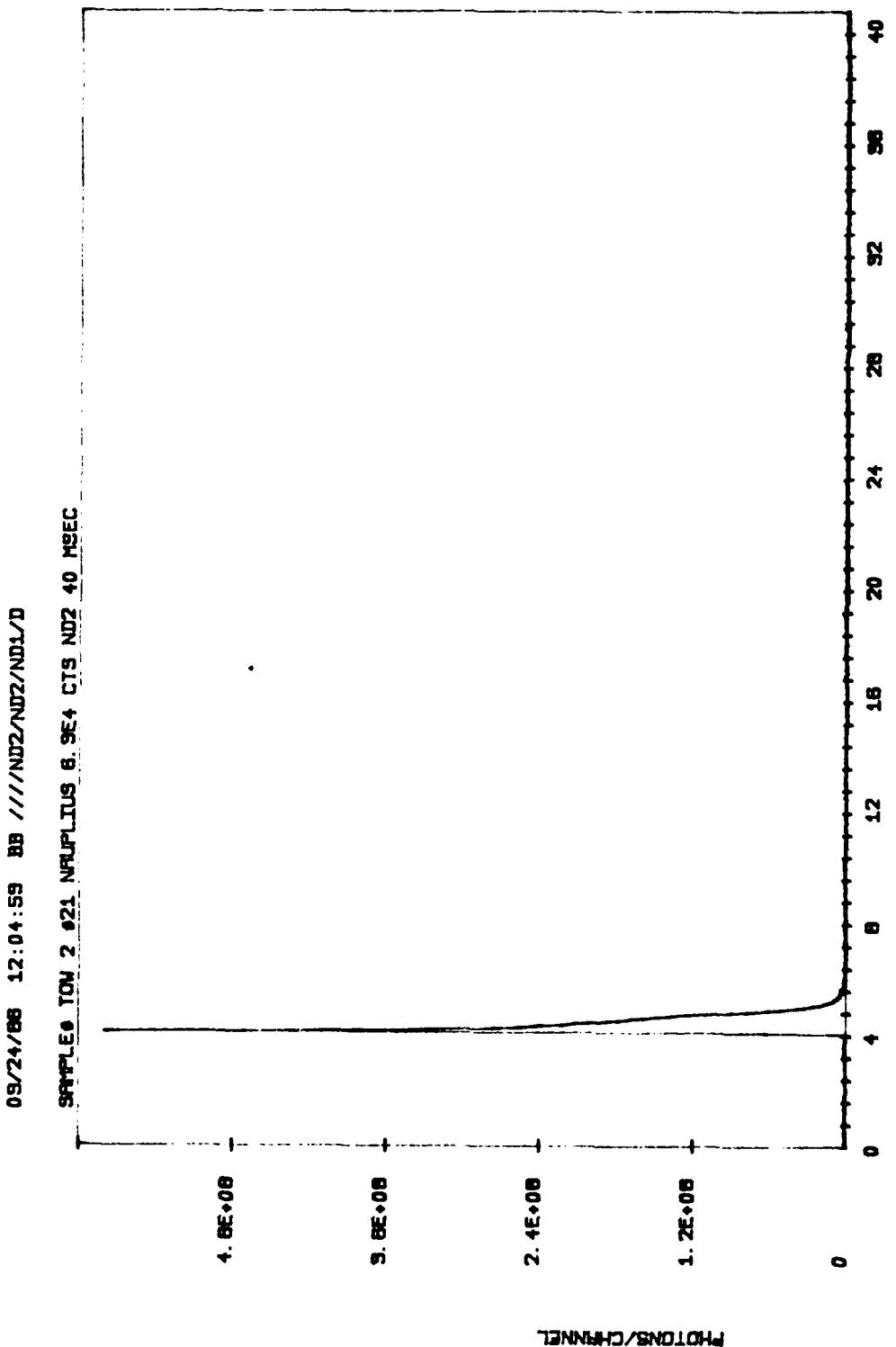


Figure C-27

09/24/68 12:24:59 BB ////ND2/ND2/ND1/D
SAMPLE TOW 2 6149 NRUPLTUS 1E5 CTS ND2 40MSec

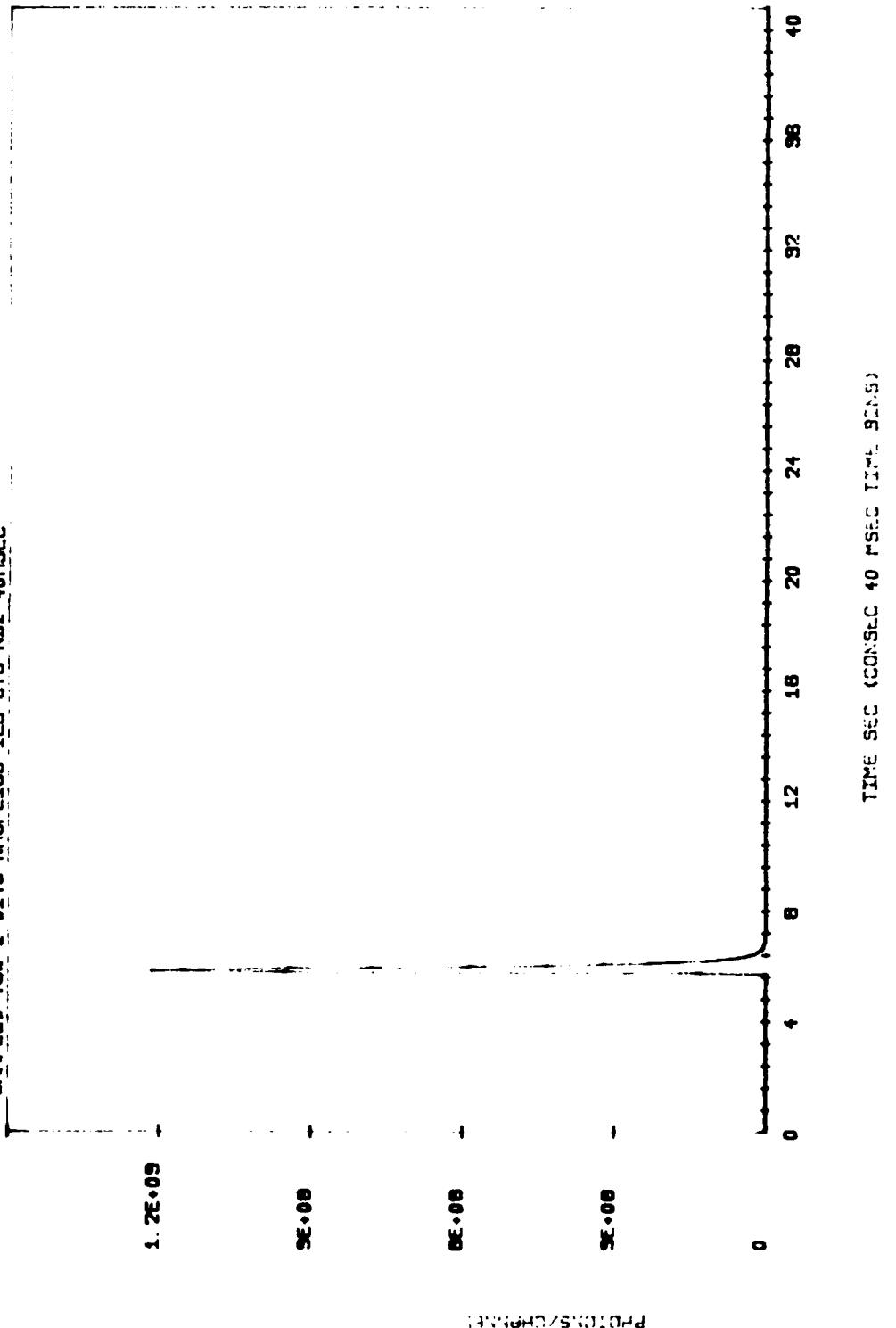


Figure C-28

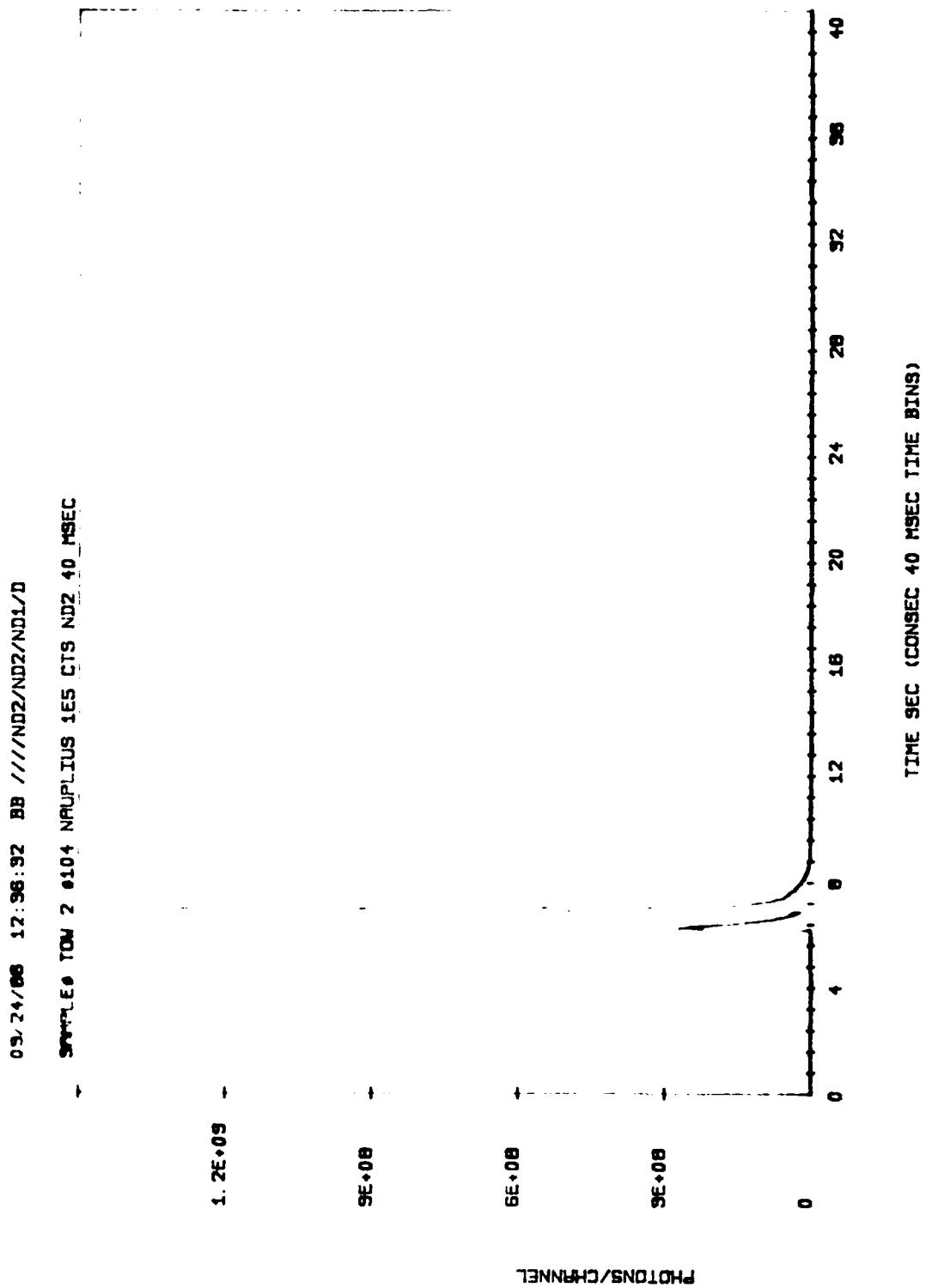
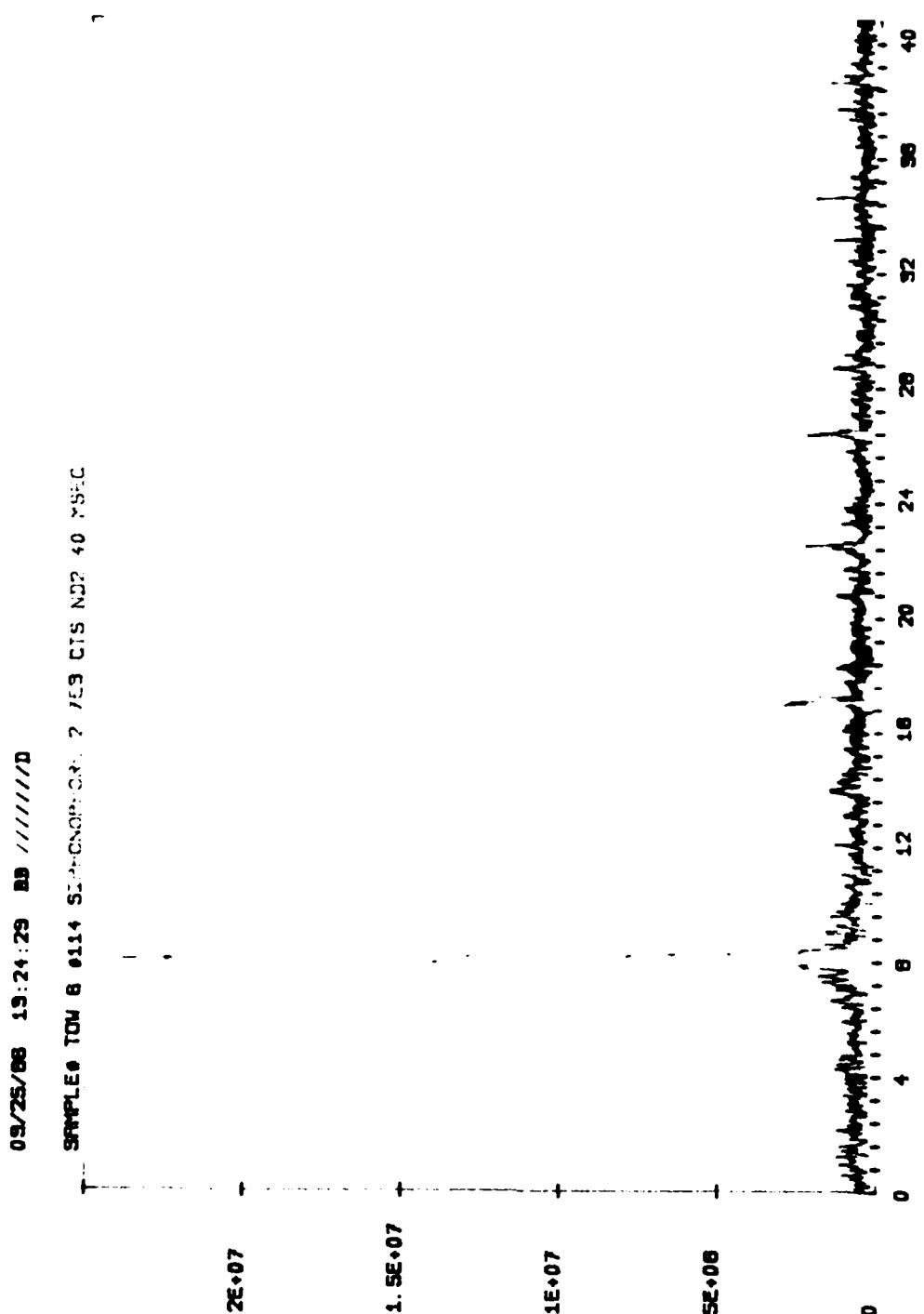


Figure C-29



PHOTONS/CHANNEL

Figure C-30

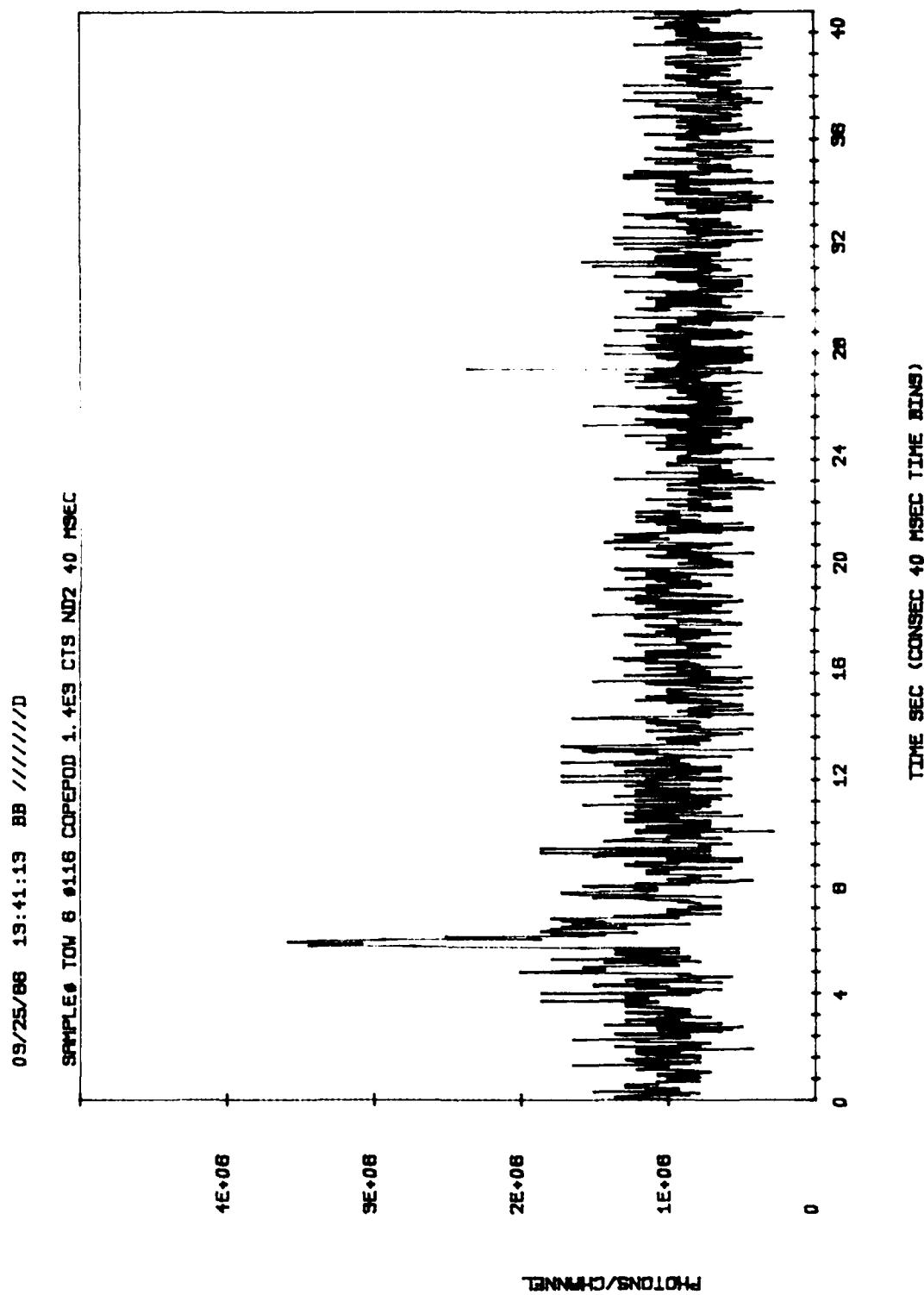
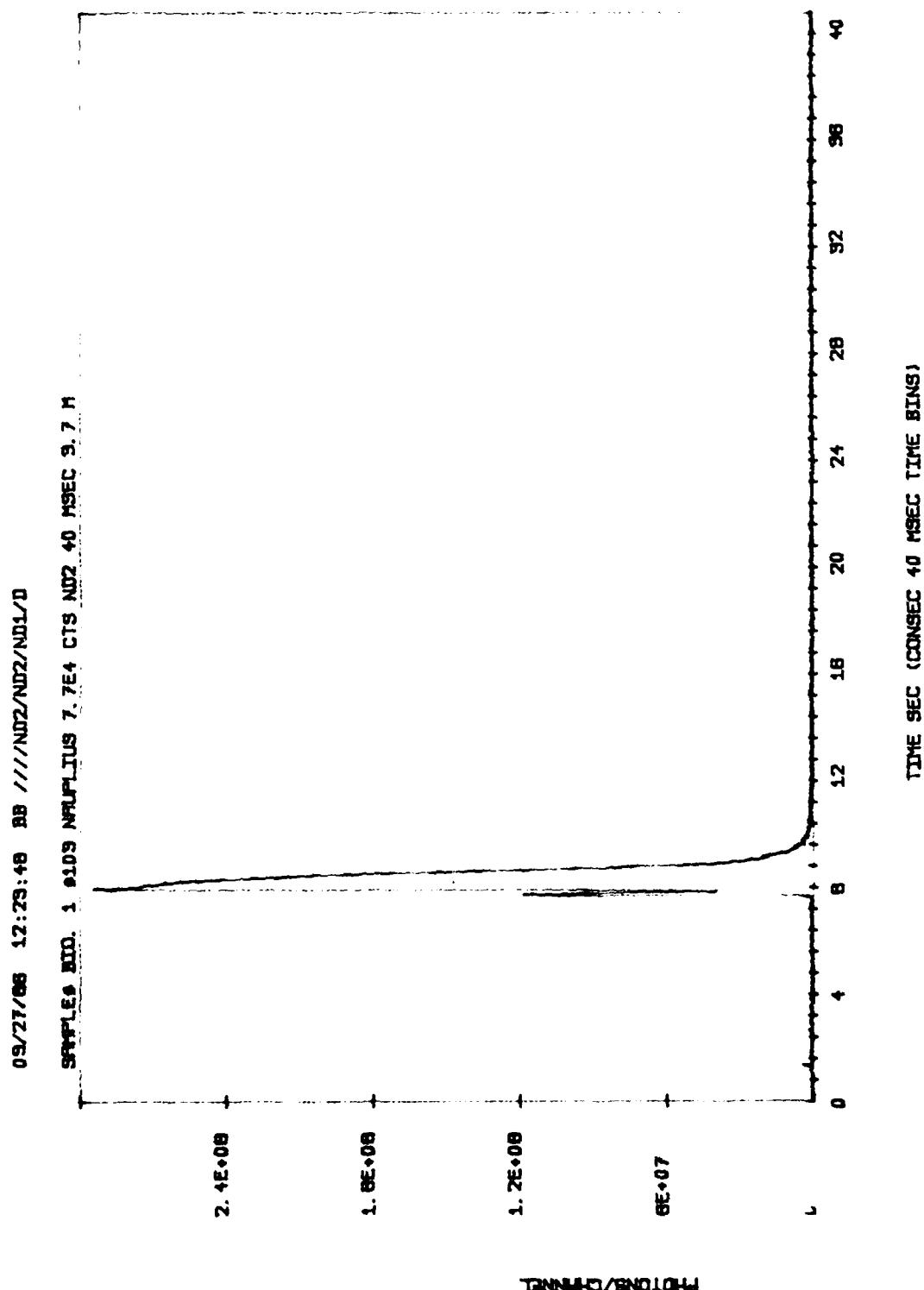
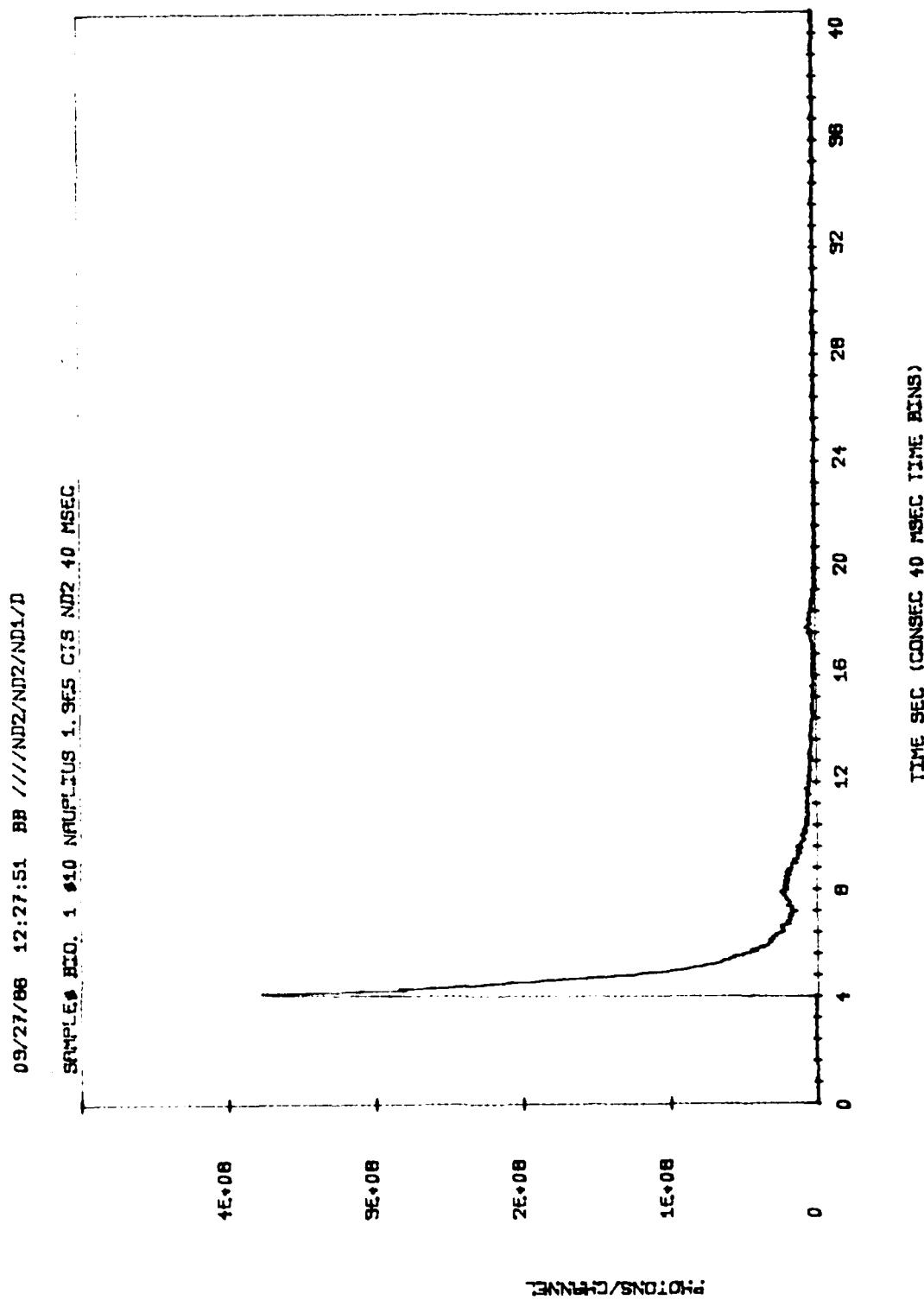


Figure C-31



C-33

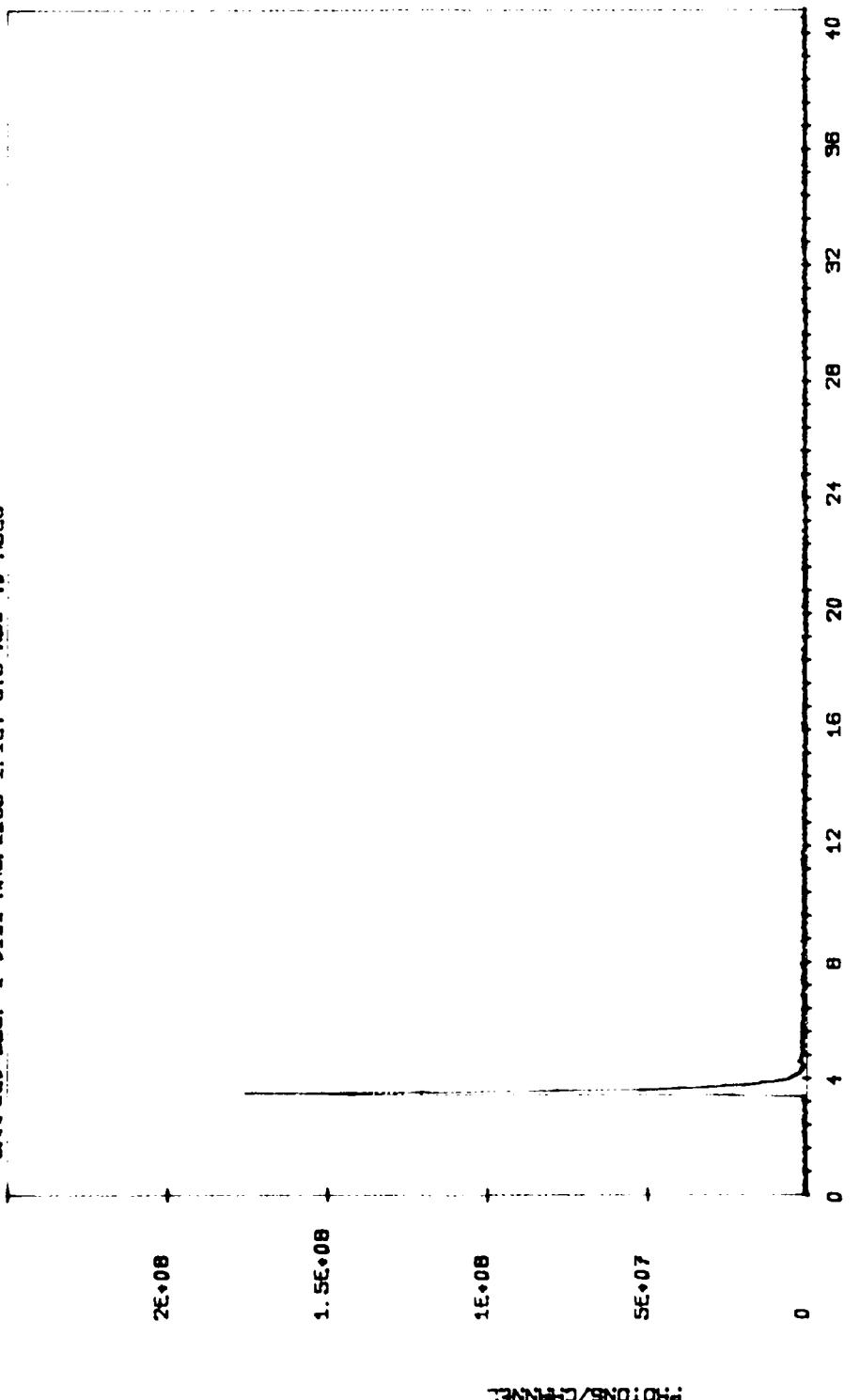
Figure C-32



C-34

Figure C-33

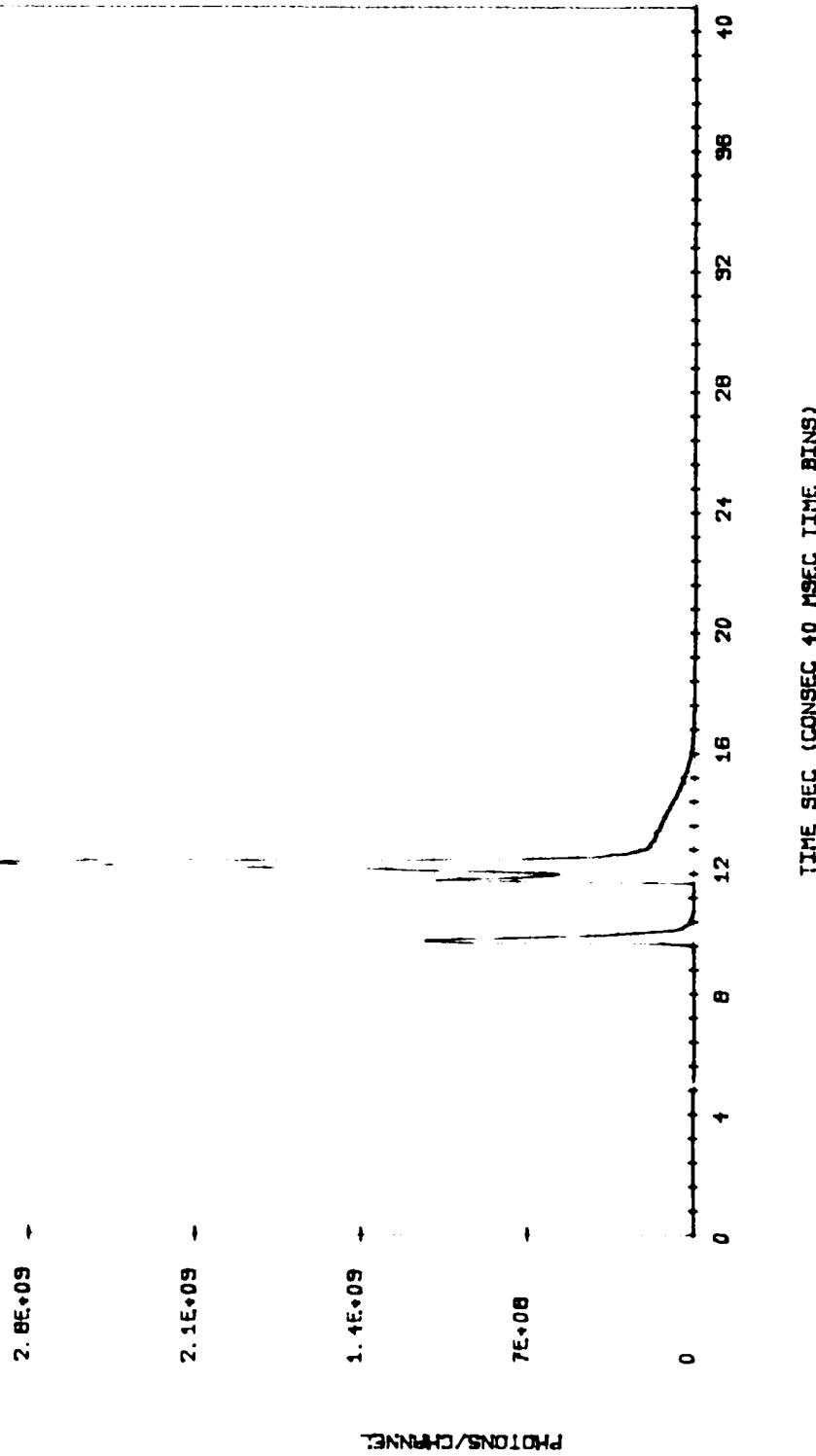
09/27/68 12:31:40 BB ////ND2/ND2/ND1/D
SAMPLE# BRO. 1 6111 NRPLIUS 1.1E4 CTS ND2 40 MSEC



C-35

Figure C-34

09/27/86 19:22:58 BB ////ND2/ND2/ND1/D
SAMPLE TOW 8 #128 COPEPOD 6.5E5 CTS ND2 40 SEC



C-36

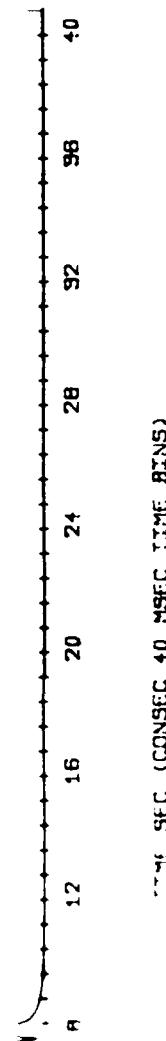
Figure C-35

09/27/86 19:31:22 BB //ND2/ND1/D
SNTRE# TOW# \$166 METRDEM 7.255 CTS ND2 40 msec

16.10

7.54.09

1.009

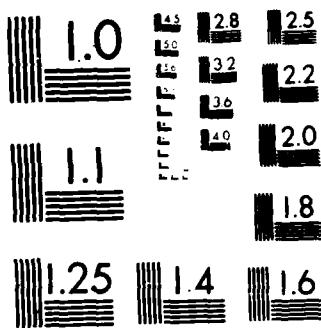


TIME SEC (CONSEC 40 msec TIME BINS)

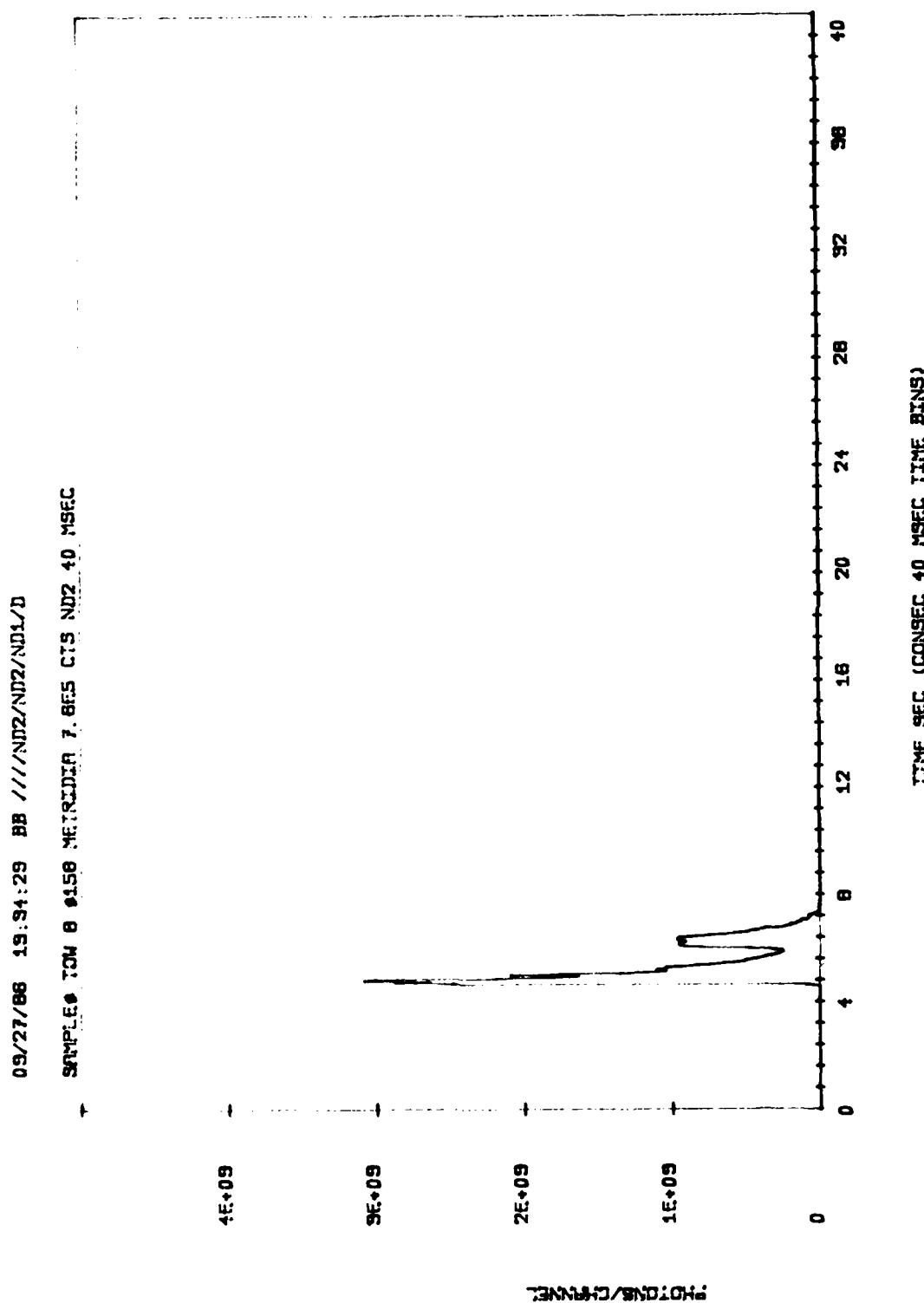
Figure C-36

AD-A179 818 BIOLOGICAL ENVIRONMENTAL ARCTIC PROJECT (BEAR)
PRELIMINARY DATA (ARCTIC WEST SUMMER 1986 CRUISE)(U) 2/2
NAVAL OCEAN SYSTEMS CENTER SAN DIEGO CA
UNCLASSIFIED D LAPOTA ET AL NOV 86 NOSC/TD-1043 F/G 8/3 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A



C-38

Figure C-37

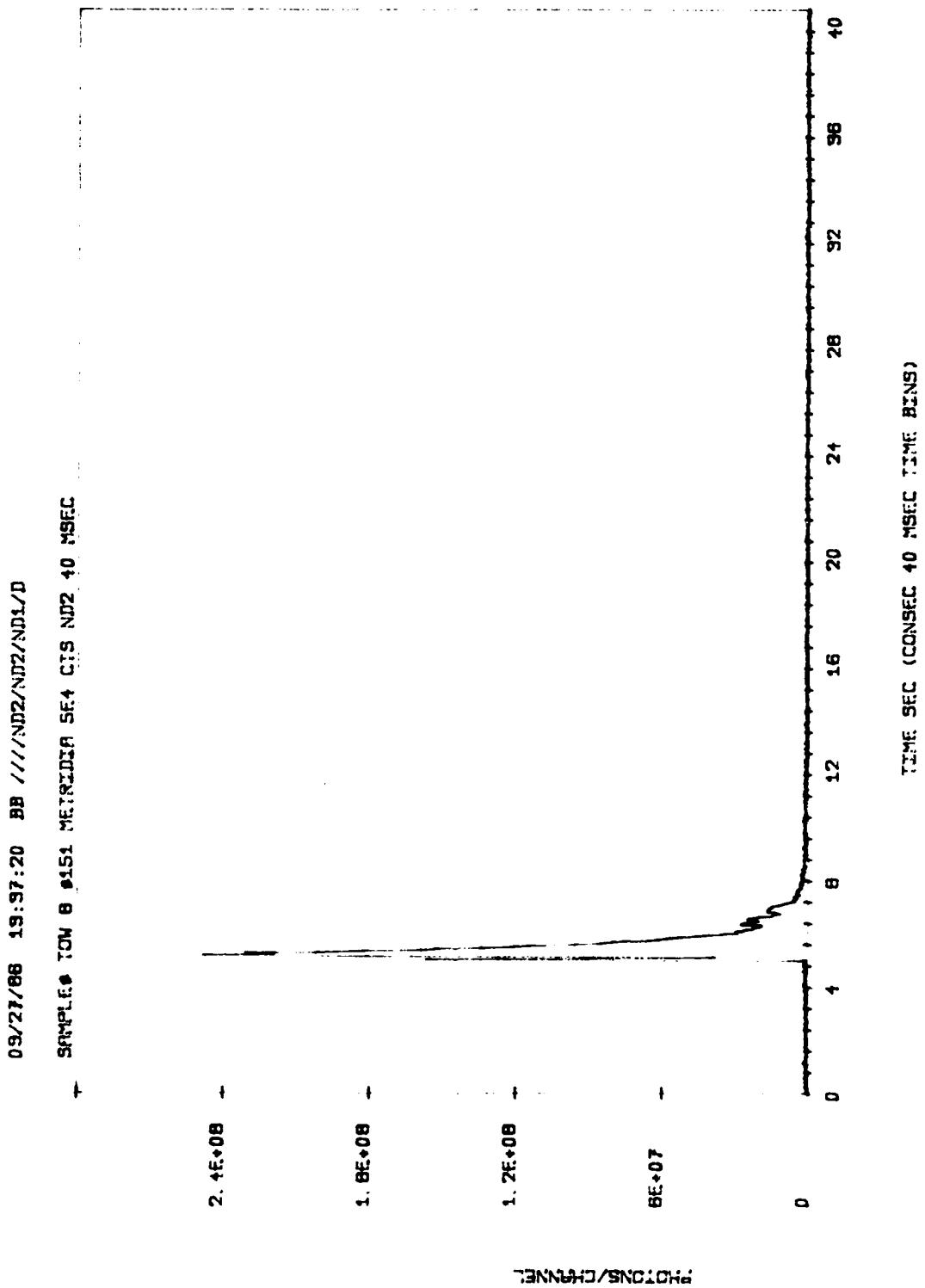
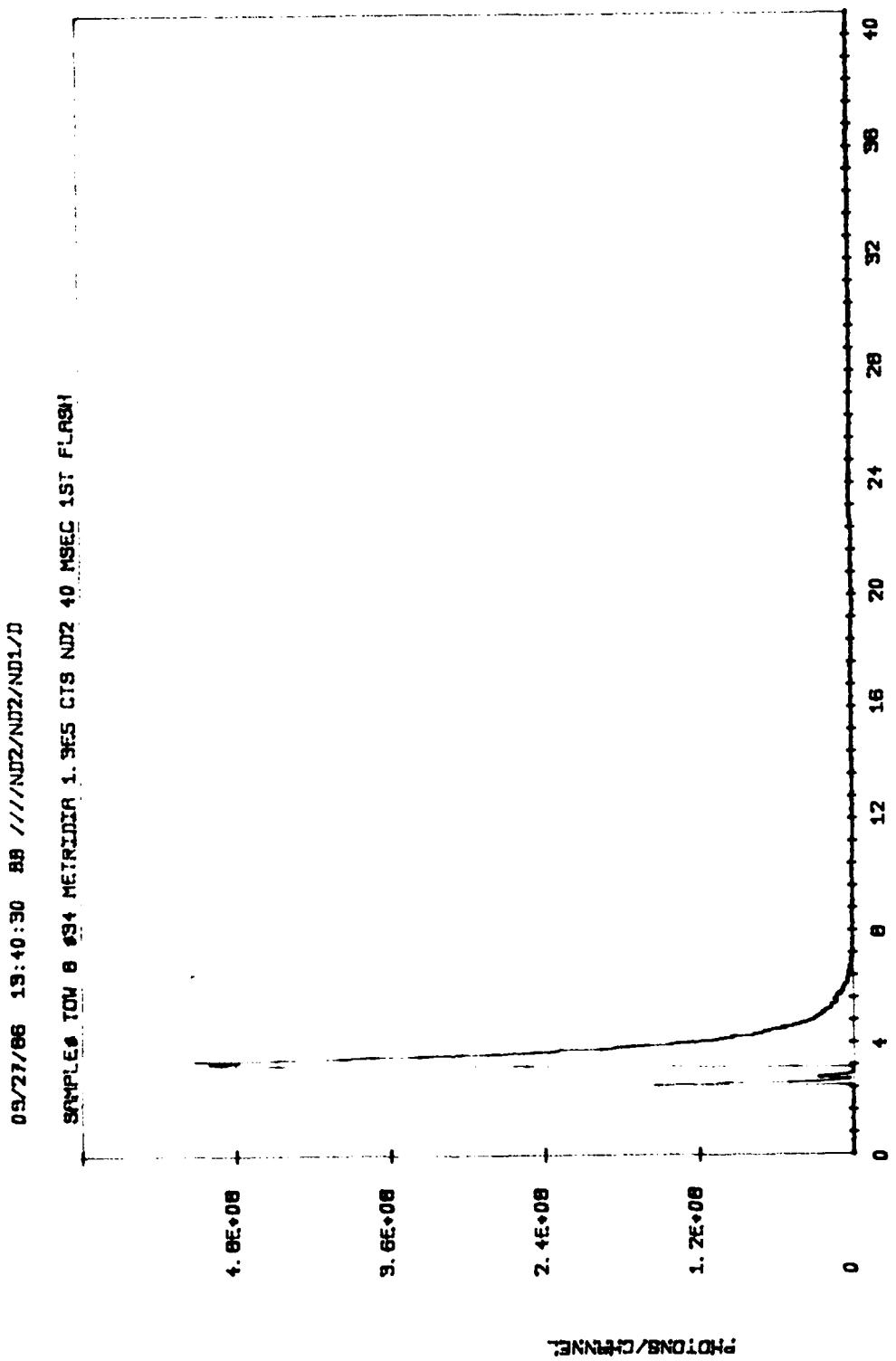


Figure C-38



C-40

Figure C-39

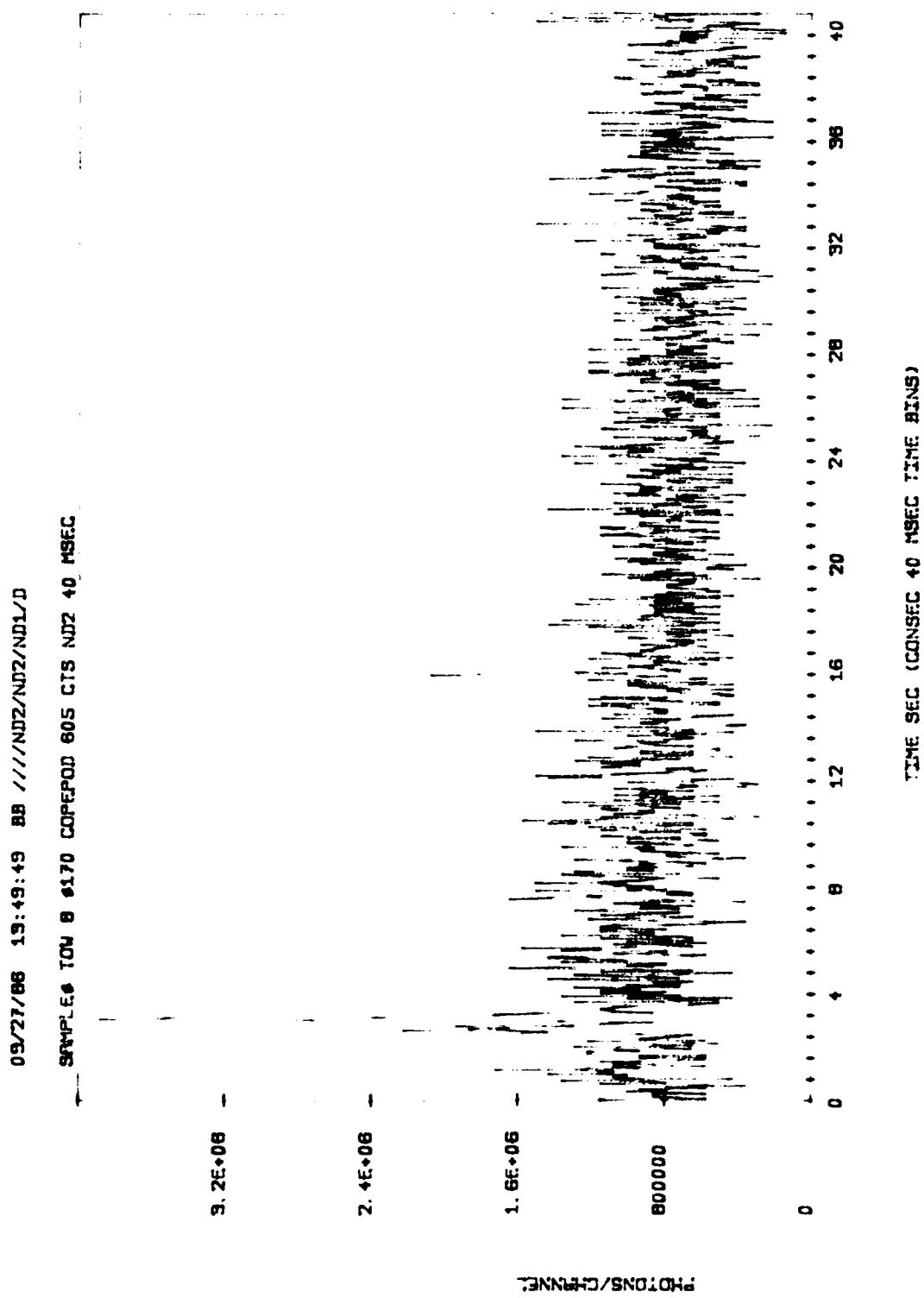
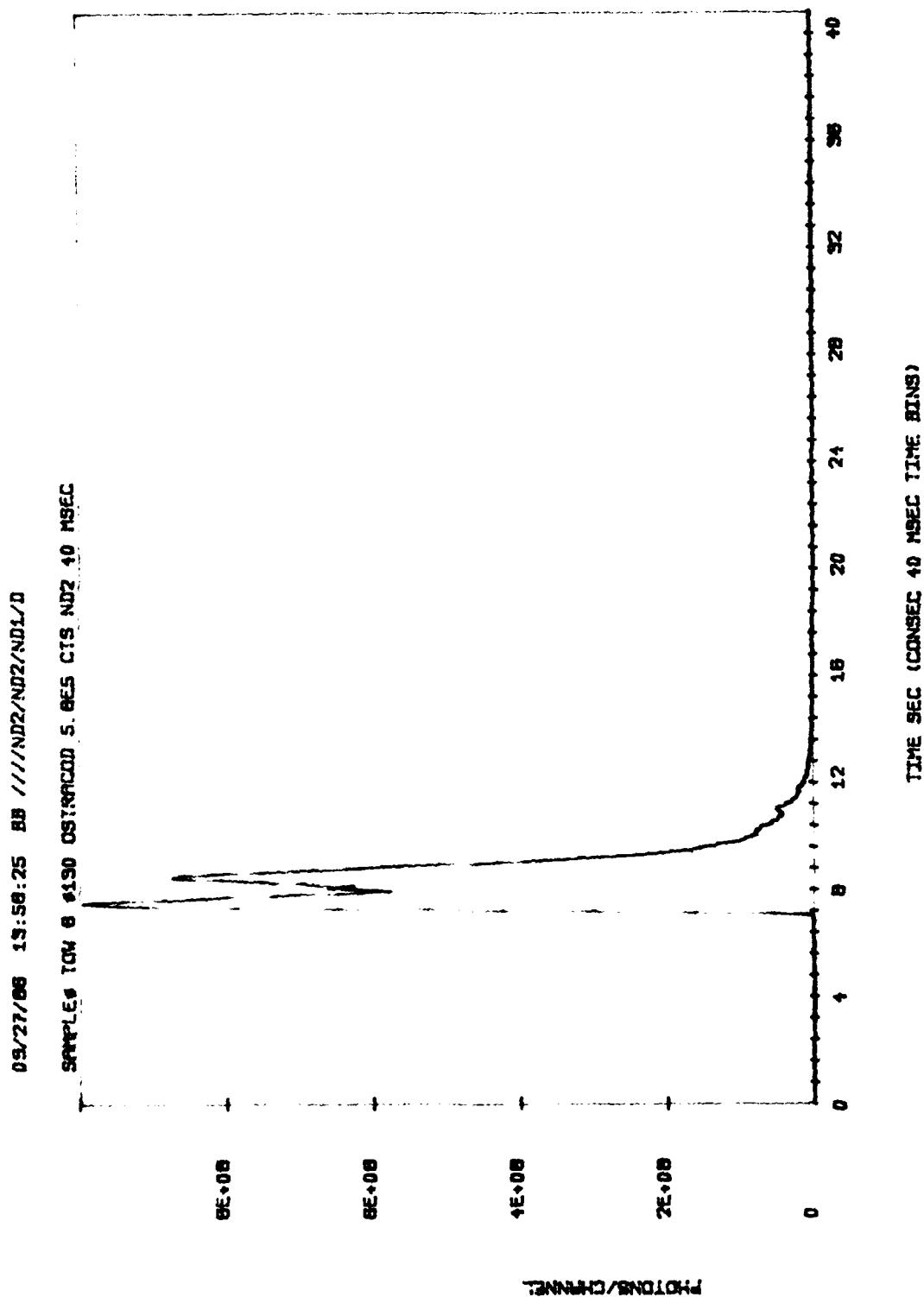


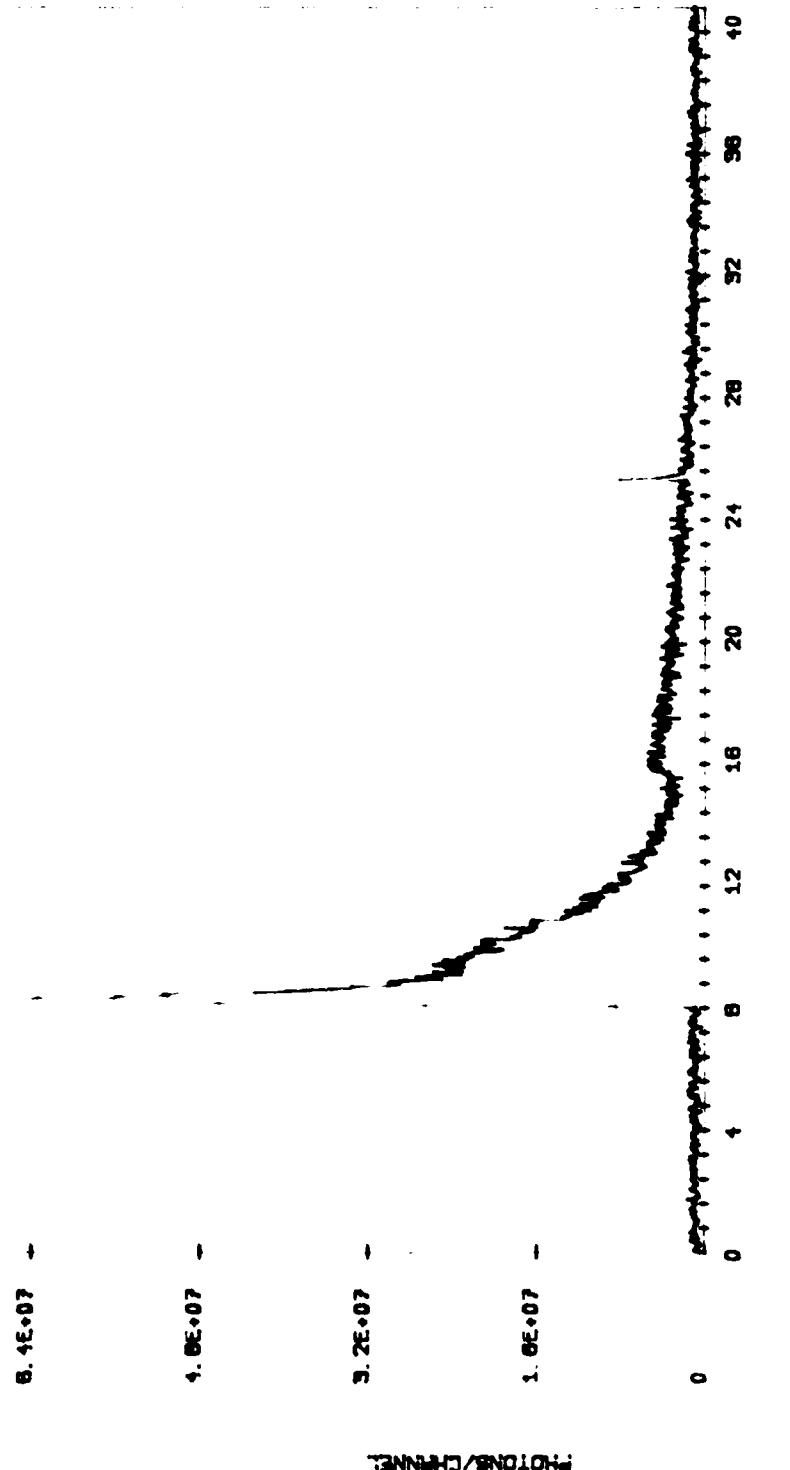
Figure C-40



C-42

Figure C-41

09/27/86 14:06:38 BB ////ND2/ND2/ND1/D
SAMPLE T0V 8 0181 COREROD SEC CTS ND2 40 NSEC



C-43

Figure C-42

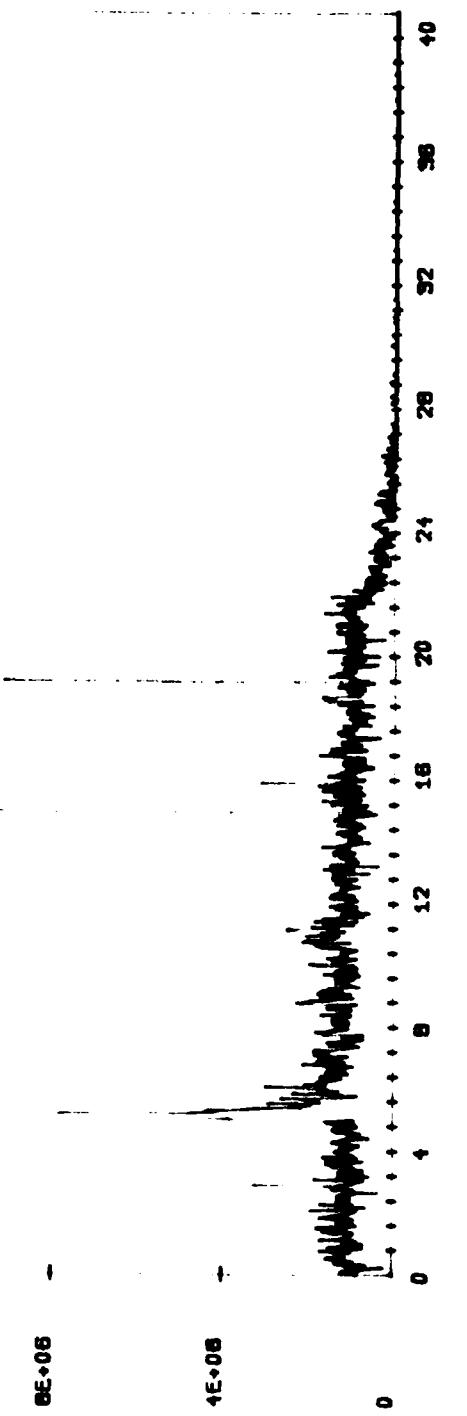
09/27/68 14:32:29 BB ////ND2/ND2/ND1/D
SAMPLE TOW 9 6180 SIPHONOPHORE 2000CTS ND2 40 MSEC

1. 8E+07 -

1. 2E+07 -

PHOTON/G CHANNEL

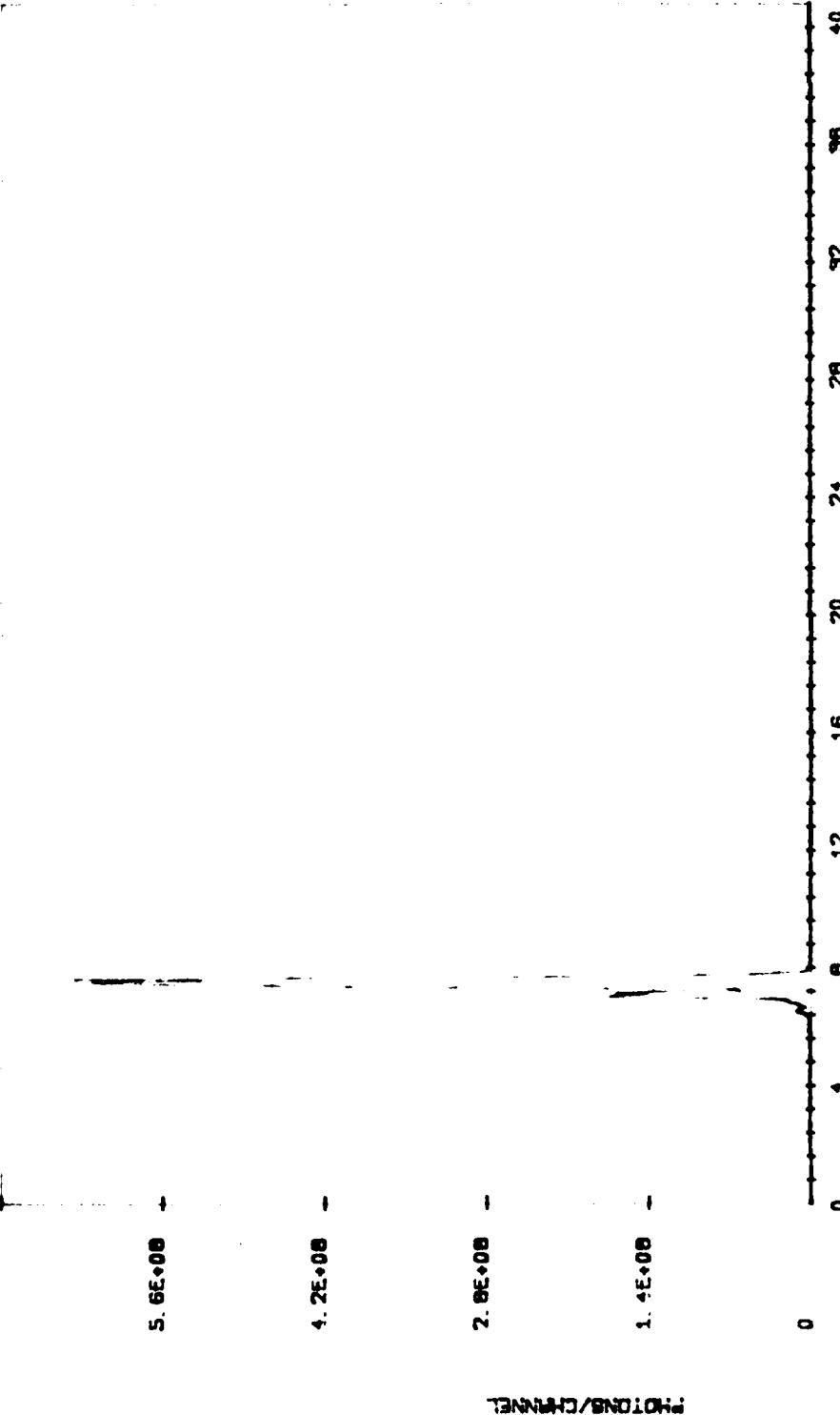
C-44



TIME SEC (CONSEC 40 MSEC TIME BINS)

Figure C-43

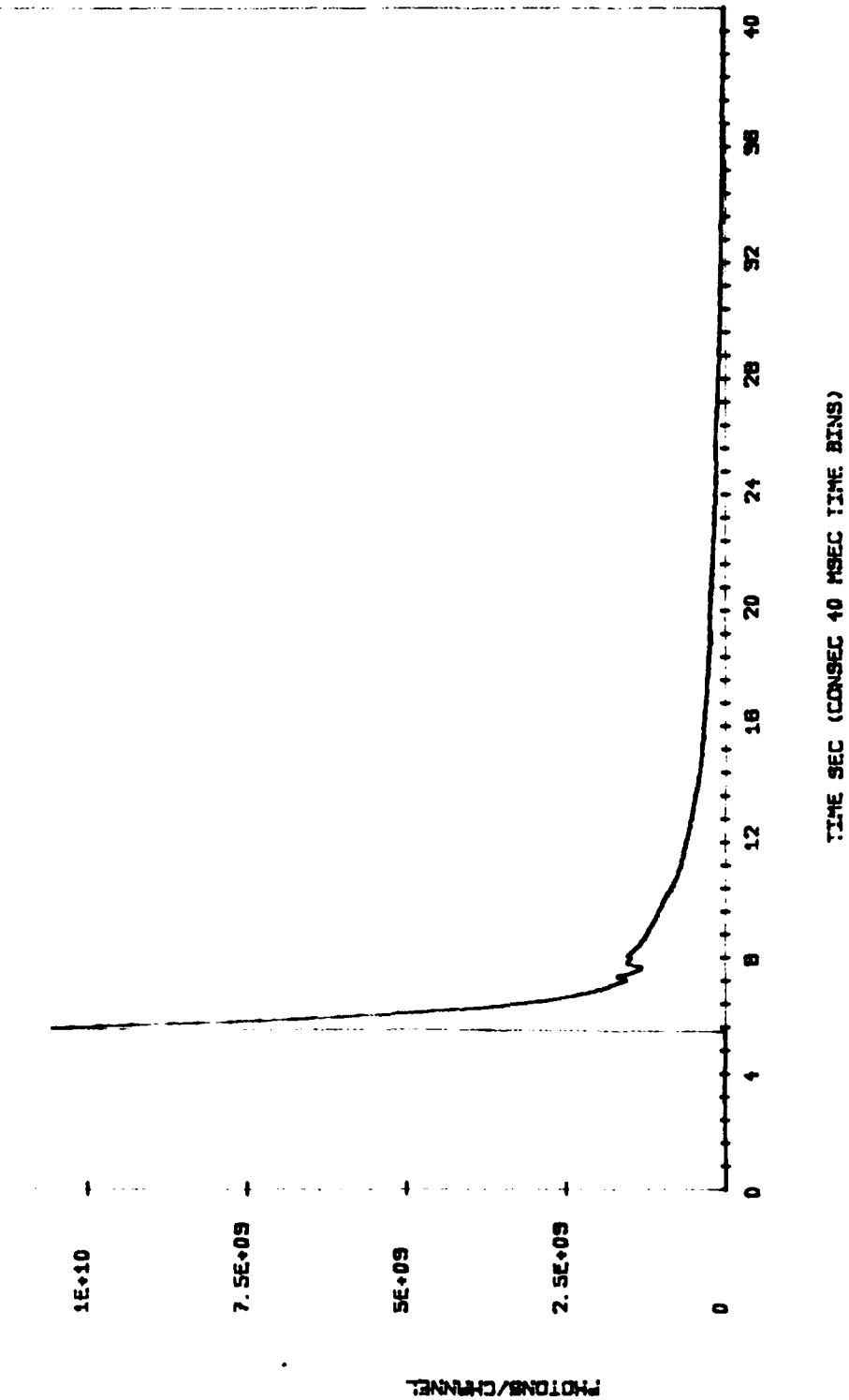
09/29/68 14:31:27 BB ////ND2/ND2/ND1/D
SAMPLES TON 9 #170 DST:RAC00 8. SEC4 C15 ND2 40 MSEC



TIME SEC (CONSEC 40 MSEC TIME BINS)

Figure C-44

09/29/86 14:49:50 BB ////ND2/ND2/ND1/D
SAMPLE T0H 10 METRIDIUM 5.88E8 CTS ND2 40 MSEC



C-46

Figure C-45

09/29/68 14:48:55 BB ////ND2/ND2/ND1/D
SAMPLE TOW 1.0 0104 METRIDIA 8.58E5 CTS 1ST FLASH: 1. 77E5 CTS 2ND FLASH ND2 40 NSEC

3. 2E+09

2. 4E+09

1. 8E+09

8E+08

PHOTONS/CHANNEL

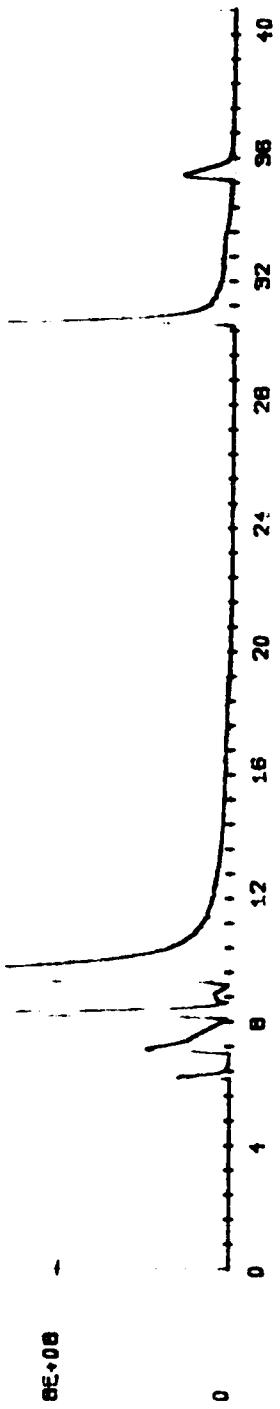
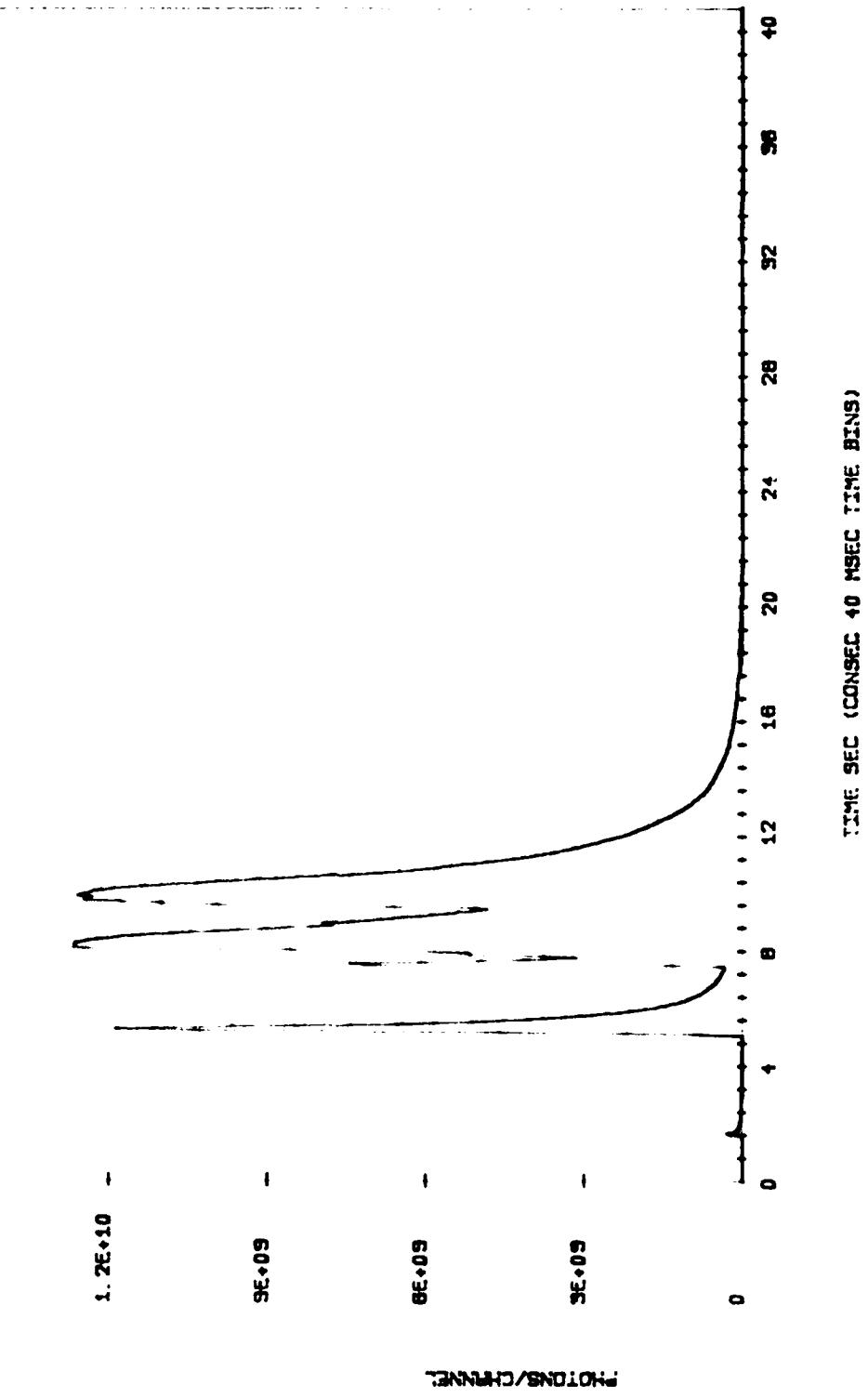


Figure C-46

09/29/86 14:51:10 BB ////ND2/ND2/ND1/D
SAMPLE# TAU 10 #180 METRIC DIR 1.5E7 CTS ND2 40 msec



C-48

Figure C-47

03/29/66 14:54:29 BP ////ND2/ND2/ND1/D
SAMPLE# TOW# 10 *110 COPEPOD S. 1E9 CTS ND2 40 MSEC

5. 8E+08 -

4. 2E+08 -

2. 8E+08 -

1. 4E+08

0 0 4 8 12 16 20 24 28 32 36 40

TIME SEC (CONSEC 40 MSEC TIME BINS)

Figure C-48

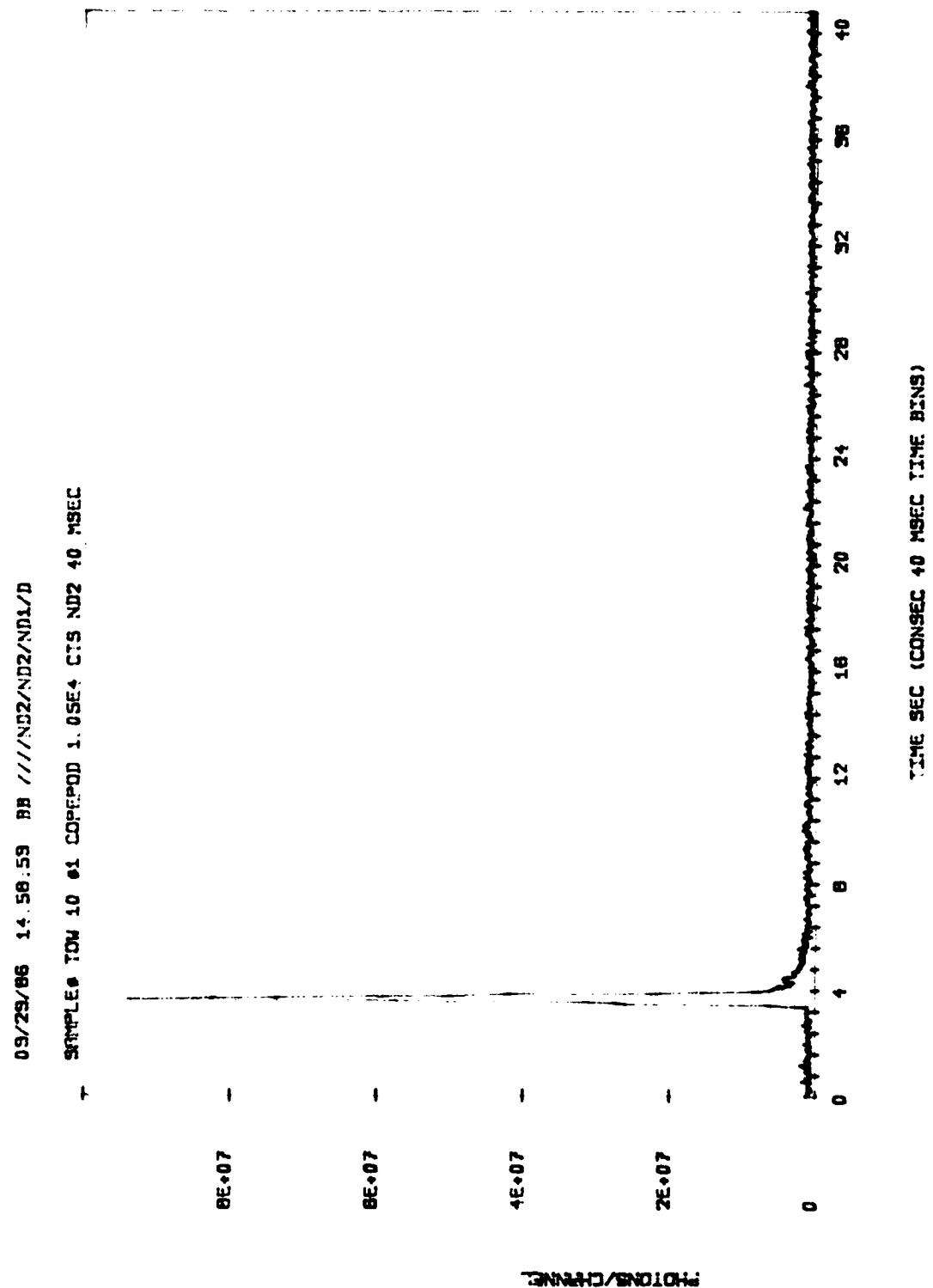
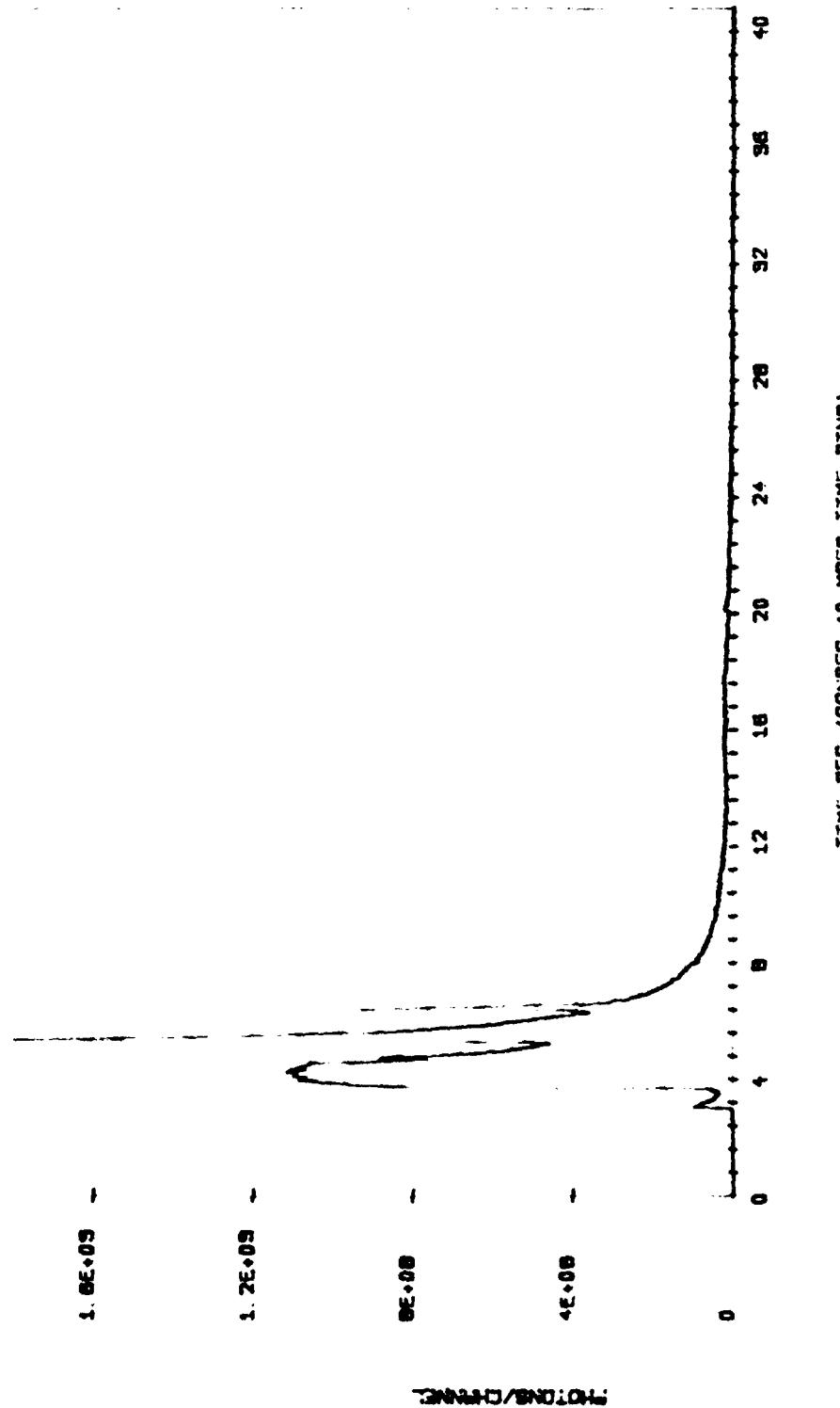


Figure C-49

09/29/68 15:09:25 BB ////ND2/ND2/ND1/D
SAMPLE T01 10 #29 COPPER 1.08E8 CTS ND2 40 SEC



C-51

Figure C-50

09/30/68 08:25:17 BB ////ND2/ND2/ND1/D
SAMPLE TOW 14 0146 PROTOPERIDENIN 40 MSEC ND2

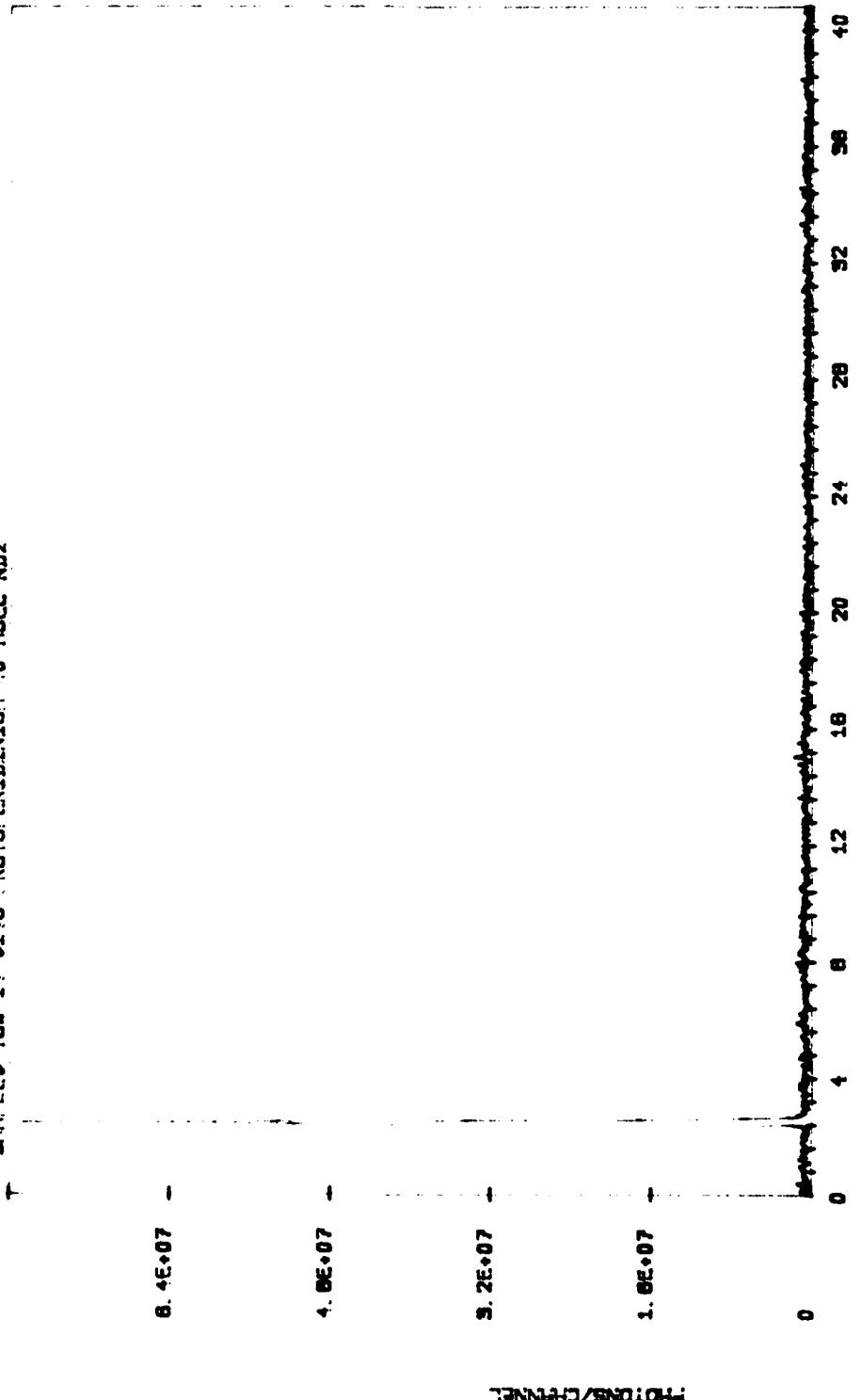


Figure C-51

09/30/86 08:31:27 BB //ND2/ND2/ND1/D
SAMPLE TAN 14 07 PROTOPIDINIUM 2 2E9 CT9 ND2 40 SEC

4E+07 -
3E+07 -
2E+07 -
1E+07 -

PHOTON/S/CHANNEL

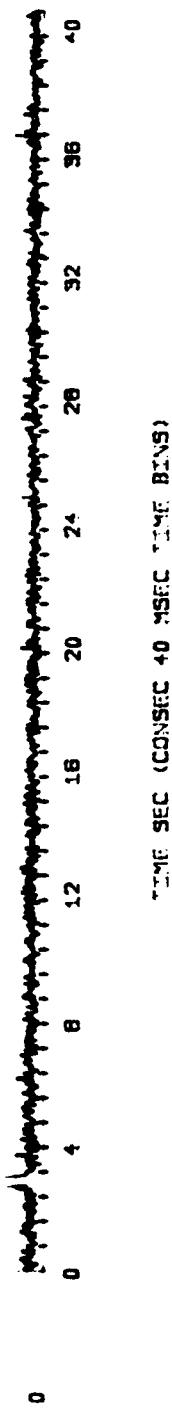


Figure C-52

09/30/68 08.58.10 BB //ND2/ND2/ND1/D
T SAMPLE TOW 14 0108 PROTOPERIODINIUM 5 1E9 CTS ND2 40 SEC

1E+08 -

7. 5E+07 -

PHOTONS/CHANNEL

C-54



Figure C-53

E N D

5 - 87

DTic